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Federal Science Activities

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FOREWORD

Increased investment in research, development and innovation is basic to the economic development of Canada. This led the federal government to establish in January 1981, a planning framework which calls for substantial increases in research and development (R&D) investment by all sectors. The 1981 budget paper entitled *Economic Development for Canada in the 1980s* also singled out R&D and innovation as key to the economic renewal of Canada.

This sixth report on Federal Science Activities describes:

- the progress made towards achieving the national target set out in the R&D planning framework in Canada by each of the main R&D sectors; and
- the scientific and technical activities carried out by the federal government and the resources it proposes to allocate to them during the fiscal year 1982/83.

A related publication, *Science Expenditures and Personnel 1982/83*, backs up this present report with detailed statistical data about federal science expenditures made within the government sector, as well as in industry and in universities. Both documents are distributed to Members of Parliament, to science-based organizations and to the public at large.

The gathering of this information is not an easy task. I would like to thank the many federal departments and agencies which have helped by providing details of their scientific activities. In particular, I would like to mention the assistance received from the Treasury Board Secretariat and from Statistics Canada.

John Roberts

HIGHLIGHTS

CANADA'S R&D TARGET IN NATURAL SCIENCES

- Canada's 1985 target for investment in research and development (R & D) in the natural sciences is 1.5% of our Gross National Product (GNP).
- This R & D investment reached 1.07% of GNP in 1981. It has grown substantially from its 1976 level of 0.94% and its 1979 level of 1.00%.
- The combined investment by government, industry and universities in R & D (natural sciences) has increased by 34% since the target and the R & D Planning Framework were established....from $2.63 billion in 1979 to $3.52 billion in 1981.
- Investment by industry in R & D (natural sciences) has risen by 43% since 1979.
- Investment by the federal government in research and development increased by 34% during the same period.

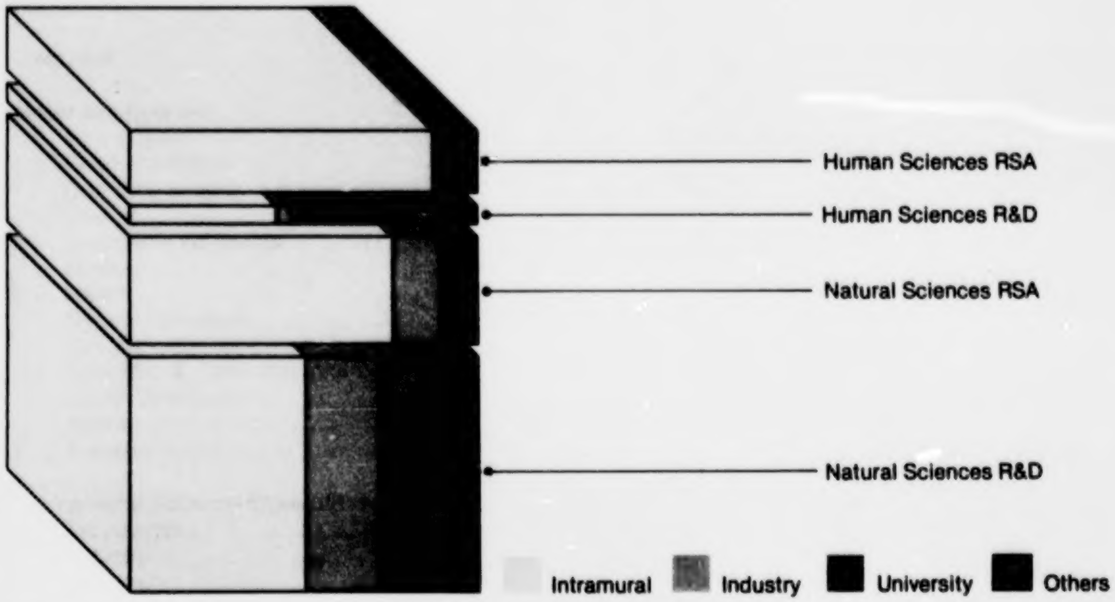
1982/83 FEDERAL SCIENCE EXPENDITURES

- Total federal science expenditures for both human and natural sciences will be $2.94 billion in 1982/83. This is an increase of about 13% over the $2.6 billion spent in 1981/82.
- In the natural sciences federal budgetary expenditures on R & D will increase by $250 million to a total of $1.8 billion in 1982/83....an increase of over 16%.
- Federal funding of R & D performed by industry will be about $390 million.
- Direct federal support to R & D performed in the universities will reach $350 million.
- Federal funding for energy R & D will increase by 26% over the previous year to reach $338 million in 1982/83.
- R & D and related scientific activities in the human sciences are estimated at $578.9 million in 1982/83.
- University research in the human sciences will increase by 18% to $61.7 million.

Chart A illustrates the distribution of federal science expenditures between performers and activities in 1982/83.

A

Federal Budgetary Science Expenditures by Activity and Performer. (1982/83)



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1. Introduction

This report is a companion publication to the 1982/83 Main Estimates. In presenting its Main Estimates to Parliament the government spells out the objectives of its departments and agencies and identifies the program expenditures designed to achieve those objectives. The published Estimates present program expenditures in general terms common to all departments of government. In contrast, this publication presents only that portion of the expenditures proposed in Main Estimates which will be applied to scientific activities.*

Aspects of the federal involvement in the support of science which do not appear in the Estimates (such as the costs of R & D tax incentives) are *not* included in the expenditure tabulations presented in this report. A major purpose of this report is to assist parliamentarians, managers, scientists and the public generally to obtain a better appreciation of the scope and purposes of the government's participation in the funding or the performance of scientific and technological activities. Much effort by many people and organizations goes into the preparation of this report. To assist in making the publication as useful as possible, interested readers are cordially invited to forward comments or suggestions for improvement to the Ministry of State for Science and Technology.

The government funds activities in science and technology (S & T) which are performed intramurally in its own establishments or extramurally in other sectors of the economy, such as the University, Industry or Provincial sectors. S & T activities are undertaken and funded to assist departments and agencies to reach their individual objectives. Departmental expenditures often contribute at the same time to the attainment of broader cross-departmental objectives of government, such as encouragement of economic development or encouragement of research into problems of national concern.

There are some 60 departments and agencies reporting scientific expenditures undertaken within a total of over 100 Budgetary Programs, each with its own goals and objectives. Against this background one can perceive three major roles which the federal government plays in its support of research and development (R & D). Broadly speaking, when government funds or performs R & D it can be said to be acting either in support of industry, in support of university research, or to attain some specific departmental mission, such as ensuring the safety and efficacy of human and veterinary drugs in Canada.

Within the present publication, departmental and agency programs are listed according to the format used in the Estimates. Federal agencies are grouped within the Portfolio of the Minister through whom they report to Parliament, for example, Statistics Canada is listed under the Supply and Services Portfolio and the Medical Research Council under the National Health and Welfare Portfolio.

The Overview section which follows this Introduction summarizes the budgetary science expenditures of the federal government. It highlights such things as overall expenditures, R & D expenditures, the government's R & D planning framework and science expenditures by major departments and agencies.

Following the Overview, the Major Applications section focuses attention on science activities within certain broad areas of national concern such as energy, in which activities and expenditures may be undertaken by a number of federal departments or agencies.

Next comes a section entitled Extramural Science Expenditures highlighting the scientific activities funded by the federal government but carried out by other sectors (including industry, universities, other levels of government, or in other countries.)

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* For explanations of terminology used in discussions of science expenditure data, please refer to Appendix I.

A Major Participants section follows, which focuses on the organization and expenditures of the scientific and technological programs and activities of those departments and agencies which have the largest science expenditures, or whose activities are exclusively scientific and technological.

The Regional section discusses the regional distribution of federal science expenditures and includes notes on federal regional establishments. Finally, the publication includes explanatory notes on the collection and definition of various aspects of the federal science expenditures, and it concludes with a table of scientific expenditures set out by department and by Parliamentary Vote.

2. Overview

The R&D Planning Framework

In 1980, the Ministry of State for Science and Technology reviewed the contribution R & D makes to the economic and social development of Canada. The federal government subsequently endorsed an R & D Planning Framework for the natural sciences. The Framework established a national target for R & D investment to reach 1.5% of GNP by 1985. To meet the target, overall expenditures on R & D in Canada must increase by 20% annually.

The required rate of increase varies from sector to sector. Industry faces the greatest challenge and must increase its R & D investment by 27% per year to reach its target. The target increase for the federal government is 17% per year.

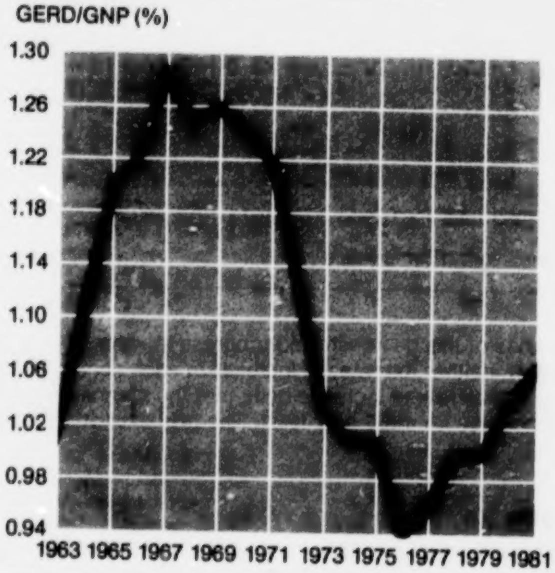
The Planning Framework and Canada's Gross Expenditures on R&D

Statistics Canada recently estimated that Canada's Gross Expenditures on R & D (GERD) have increased by 34% since 1979 from $2.63 billion to $3.52 billion in 1981. The GERD now corresponds to 1.07% of GNP in 1981 compared to 1.00% in 1979. The downward trend in the GERD/GNP ratio which was evident in the early seventies has been arrested and reversed in recent years (Chart 2.1).

From 1979 to 1981, the increases in R & D investment by the private sector and the federal government have been particularly impressive. Investment in R & D by industry has risen by 43% ($447 million) from $1,034 million to $1,481 million in these two years. The 21.3% growth rate achieved by industry in 1981 was higher than the 18.1% rate achieved in 1980. In real terms, these growth rates are higher than in any period since the early 1960's (Chart 2.2).

2.1

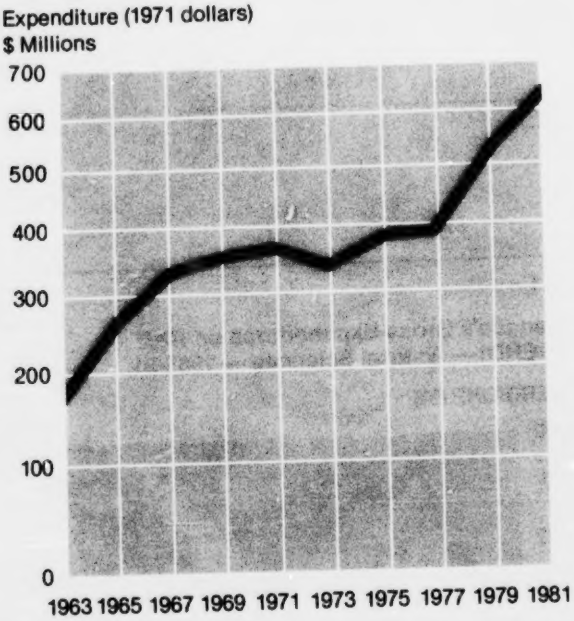
Canada's Gross Expenditures on R&D (GERD) — Natural Sciences — 1963-81.



The federal government's gross expenditures on R & D in the natural sciences have also increased dramatically since 1979, rising from $936 million in 1979 to $1,254 million in 1981. This represents an increase of $318 million or 34%. This GERD estimate of $1,254 million for 1981 is actually slightly understated as it does not take into account the additional federal R & D expenditures contained in Supplementary Estimates for 1981/82 fiscal year.

2.2

Gross Expenditures on R&D (GERD) — by Industry Sector



semi – logarithmic scale

In spite of this demonstrated progress towards the target, neither the rates of increase in each sector nor the overall rate of increase quite met the planned rate of increase for 1980 and 1981. The only exceptions were the category of "other funders" whose investments exceeded the planned rate and the federal government which virtually met it (Table 2.1).

The Planning Framework and the Budget for R&D in the Natural Sciences

Due to definitional, timing and reporting differences, the GERD statistics published by Statistics Canada and the budgetary science expenditure data derived from the Main Estimates do not match. For example, the R & D expenditures of the Canadian International Development Agency (CIDA) and the International Development Research Centre (IDRC) are not included in GERD.

The difference between these two series of data is significant. Federal budgetary expenditures on R & D in the natural sciences in 1980/81 totalled $1,240 million while the Statistics Canada estimate of the federal contribution to GERD for 1980 was only $1,105 million. The difference of $135 million represents an amount equivalent to 11 % of total federal R & D expenditures in the natural sciences.

The gap between the two expenditure series was taken into account in calculating the federal budgetary expenditures required to meet the R & D Planning Framework objectives. The target track for federal expenditures on R & D and the expenditures budgeted in the Estimates are compared below (Table 2.2).

Table 2.1

A Comparison of Planned and Actual Increases in GERD by Funder

Funder Sector	1979	1980	1981	Annual Average Rate of Growth	
				Planned	Actual
	(millions of dollars)				
Federal Government	936	1,105	1,254	17 %	16 %
Provincial Government	173	194	213	19 %	11 %
Industry	1,034	1,221	1,481	27 %	20 %
University	344	346	387	9 %	6 %
Other	144	163	183	9 %	13 %
Total	**2,631**	**3,029**	**3,518**	**20%**	**16%**

Table 2.2

R&D in the Natural Sciences: Actual and Estimated Federal Expenditures

Year	Target Track	Original Estimates	Revised Estimate	Above (Below) Track
		(millions of dollars)		
1979/80	1,100	1,100	1,100	—
1980/81	1,282	1,298	1,240	(42)
1981/82	1,493	1,495	1,534	41
1982/83	1,738	—	1,784	46

The estimated 1982/83 expenditures for R & D in the natural sciences are $1,784 million, $46 million above the target track level of $1,738 million established in the Planning Framework. Expenditures in 1981/82, estimated at $1,534 million, also exceed the track by $41 million. In the first year of the Planning Framework, expenditures were originally estimated at $1,298 million. Actual expenditures for that year were $1,240 million, $42 million below the target track.

The federal government's high priority placed on R & D investment is evident when compared to other federal demands for funds. During the first two years of the Planning Framework, R & D expenditures in the natural sciences increased by about 39%. In the same period the government's total operating and capital expenditures for all departments and agencies only increased by about 22%.

The Planning Framework and the Allocation of New Funds for R&D in the Natural Sciences

All funds for program development or for new projects must be financed from the reserves of the various expenditure envelopes of the government. Between 1979/80 and 1981/82, $325 million has been allocated from these reserves for R & D activities in the natural sciences (Table 2.3).

To encourage private sector investment in R & D, the R & D Planning Framework suggested that 47% of new federal funds for research and development be applied to support R & D in industry, 21% to support R & D in universities and the remaining 32% to support departmental missions.

New funds allocated to industrial R & D support from the reserves of the expenditure envelopes totalled $225.6 million or 69%; new funds to support research

Table 2.3

Allocation from Reserve Funds (1979/80 to 1981/82)

Program	Two-Year R&D Increase	Sub-Totals
	(millions of dollars)	
Direct Industry Support R&D Component		
Defence Industry Productivity Program	24.6	
Enterprise Development Program	46.3	
Industrial Research Assistance Program	5.8	
Program for Industry Laboratory Projects	7.3	
New Technology Employment Program	1.0	
Source Development Fund	1.0	
Unsolicited Proposals	0	**86.0**
Government Programs with Industry		
Space	40.9	
Telidon	10.9	
David Florida Laboratory	6.6	
Industrial Materials Institute	8.5	
Arctic Vessel Institute	4.7	**71.6**
Government Programs Impacting Industry		
Energy R&D	97.9	
Transportation R&D	3.0	**100.9**
Support to University		
Medical Research Council (MRC)	11.6	
Natural Science and Engineering Research Council (NSERC)	47.6	**59.2**
Intramural Programs	7.0	**7.0**
Grand Total		**324.7**

in universities totalled $59.2 million or 18%; and, new funds going to departmental mission research totalled $39.9 million or 12%. This estimate assumes that $68 million of the $98 million set aside for energy has been allocated to industrial R & D support and the rest to mission-oriented research.

In summary, planned and actual expenditures on R & D in natural sciences compare very favourably and considerable progress has been made towards achieving the R & D target. The federal government has increased its expenditures in line with the target. The industry sector has also increased its own R & D investment at a very high rate by historical standards. Although the overall growth in R & D investments has not quite met the expenditure target, the past downward trend in Canada's R & D expenditures as a percentage of GNP has been reversed, and the GERD/GNP ratio is now rising steadily.

R&D and Innovation

The costs of innovation include many more costs than those directly related to R & D. Most federal departments take this into account in their industrial support programs. Table 2.4 illustrates the R & D component of a few of the major industry-support programs.

Table 2.4

The R&D Component of the Industrial Innovation Support Programs

Direct Industry Support	(1981/82) Total Program	R&D Component
	(millions of dollars)	
Defence Industry Productivity Program (IT&C)	151.6	55.9
Enterprise Development Program (IT&C)	142.0	76.7
Industrial Research Assistance Program (NRC)	31.6	25.4
Program for Industry Laboratory Projects (NRC)	16.4	16.4
New Technology Employment Program (EIC)	8.0	1.0
Source Development Fund (DSS)	10.0	1.0
Unsolicited Proposals (DSS)	15.0	12.0
Total	**374.6**	**188.3**

The Federal Science Budget—Main Estimates 1982/83

The federal science budget covers several areas of science expenditure. Aside from expenditures on R & D in the natural sciences (the measure used in the R & D Planning Framework) it also provides for expenditures on related scientific activities (RSA) in the natural sciences and both RSA and R & D in the human sciences.

Total federal budgetary expenditures in both the natural and the human sciences will be $2.94 billion in 1982/83, representing an increase of about 13% over the corresponding $2.60 billion in 1981/82. Total R & D and RSA in the natural sciences will be $2.3 billion in 1982/83, an increase of almost 17% over 1981/82. Total R & D and RSA in the human sciences will remain at $579 million, approximately the same level as the year before (Table 2.5).

Table 2.5

Federal Science Expenditures (1981/82 to 1982/83)

	1981/82	1982/83	Increase (Decrease)
	(millions of dollars)		
Human Sciences			
R&D	109.5	130.4	19%
RSA	469.7	448.5	(5%)
Total	579.2	578.9	—
Natural Sciences			
R&D	1,533.9	1,784.3	16%
RSA	491.4	578.3	18%
Total	2,025.3	2,362.5	17%
Total	**2,604.9**	**2,941.4**	**13%**

Over the past five years, expenditures for R & D in the natural sciences grew faster, at about 15% per annum, than any other component of the science expenditures. The annual growth rate of total federal science expenditures has been about 13% (Table 2.6). The growth in federal science expenditures from 1978/79 to 1982/83 is illustrated in Chart 2.3.

Table 2.6

The Five-Year Growth in Federal Science Expenditures

	Expenditures		Increase	
	1978/79	1982/83	Cumulative	Average Per Year
	(millions of dollars)			
Human Sciences				
R&D & RSA	411	579	41%	9%
Natural Sciences				
R&D	1,011	1,784	76%	15%
RSA	387	578	49%	11%
R&D & RSA	1,398	2,362	69%	14%
Total Science	**1,809**	**2,941**	**63%**	**13%**

Natural Sciences

The federal expenditures in natural sciences for 1982/83 will be $2,362 million which is $337 million (17%) more than those in 1981/82. Of this the R & D expenditures will account for $1,784 million (75.5%) while RSA activites will account for $578 million (24.5%).

Federally-funded R & D and related scientific activities are performed in-house (intramurally) and in other sectors (extramurally). The major extramural performers are industry, university, provincial governments, private non-profit organizations, and the foreign sector. The latter is funded primarily by the Canadian International Development Agency (CIDA) and the International Development Research Centre (IDRC). The distribution of natural sciences expenditures in 1982/83 is compared in Chart 2.4.

Over the past five years, federal expenditures on intramural R & D activities grew more slowly, at about 14% per annum, than extramural expenditures at 20%. Thus, while federal intramural expenditures accounted for 58% of total federal R & D expenditures in 1978/79, they now represent a 51% share in 1982/83 (Table 2.7).

During this same period, federal expenditures for R & D performed in industry have been increasing by 22% per year. They more than doubled between 1978/79 and 1982/83, from $182 million to $389 million. This growth has also meant that support for industrial R & D has grown to 22% of total federal R & D expenditures from the 18% level in 1978/79.

2.3

Federal Budgetary Science Expenditures — 1978/79 to 82/83 (in current dollars)

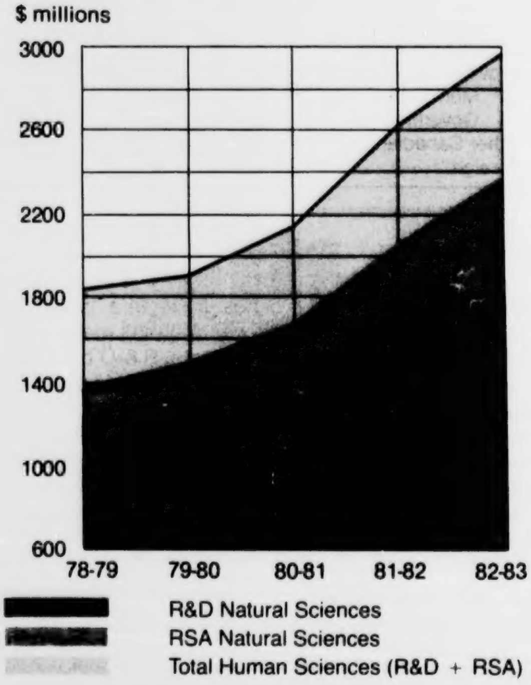


Table 2.7

Federal R&D and RSA Expenditures in the Natural Sciences by Performing Sector

(millions of dollars and (%))

	1978/79		1979/80		1980/81		1981/82		1982/83	
Total Natural Sciences	**1,397.8**		**1,494.5**		**1,677.6**		**2,025.3**		**2,362.5**	
R&D Expenditures (Total)	**1,011.2**	**(100)**	**1,100.3**	**(100)**	**1,240.0**	**(100)**	**1,533.9**	**(100)**	**1,784.3**	**(100)**
Intramural	583.4	(58)	587.8	(53)	665.3	(54)	771.2	(50)	912.8	(51)
Extramural (Total)	427.8	(42)	512.5	(47)	574.7	(46)	762.7	(50)	871.5	(49)
Industry	181.8	(18)	213.4	(19)	237.2	(19)	337.3	(22)	389.4	(22)
University	190.3	(19)	200.6	(18)	254.1	(20)	312.6	(20)	351.2	(20)
Private Non-Profit	8.3	(1)	8.9	(1)	8.6	(1)	11.8	(1)	15.3	(1)
Provincial & Municipal Governments	13.8	(1)	53.8	(5)	31.7	(3)	45.9	(3)	55.7	(3)
Other Canadian	4.3	(–)	4.3	(–)	4.3	(–)	8.0	(1)	8.7	(–)
Foreign	29.3	(3)	31.7	(3)	38.8	(3)	47.0	(3)	51.3	(3)
RSA Expenditures (Total)	**386.6**	**(100)**	**394.2**	**(100)**	**437.6**	**(100)**	**491.4**	**(100)**	**578.2**	**(100)**
Intramural	296.1	(77)	313.4	(79)	342.1	(78)	381.6	(78)	448.0	(77)
Extramural (Total)	90.4	(23)	80.8	(21)	95.5	(22)	109.8	(22)	130.2	(23)
Industry	58.0	(15)	45.8	(12)	55.4	(13)	63.2	(13)	74.7	(13)
University	13.7	(4)	15.0	(4)	19.9	(5)	25.4	(5)	28.3	(5)
Private Non-Profit	2.5	(1)	2.6	(1)	3.2	(1)	3.3	(1)	3.6	(1)
Provincial & Municipal Governments	7.5	(2)	7.4	(2)	7.4	(2)	8.4	(2)	13.9	(2)
Other Canadian	6.3	(2)	7.2	(2)	6.3	(1)	5.6	(1)	5.4	(1)
Foreign	2.4	(1)	2.8	(1)	3.2	(1)	4.0	(1)	4.4	(1)

Support for university R & D has grown at a 17% per annum rate over the past five years. It has maintained a relatively constant share of the total R & D budget at about the 20% level. Most of the current federal support for R & D performed in the universities, $351.2 million in 1982/83, is provided through the granting councils. In the natural sciences, about 80% of the federal funds are channelled through the Medical Research Council (MRC) and the Natural Sciences and Engineering Research Council (NSERC).

The total budgets of the MRC and of NSERC increased steadily from $176 million in 1978/79 to $340 million in 1982/83, a 93% increase in four years (Table 2.8). About 95% of the councils' budgets go directly to universities to support R & D and RSA activities.

The distribution of the 1982/83 R & D expenditures in natural sciences among the major areas of application is illustrated in Chart 2.5. Natural resources R & D and energy R & D account for 40% of total expenditures. Energy R & D is now the fastest growing component, increasing 26% from $268.5 million in 1981/82 to $338.2 million in 1982/83.

Human Sciences

Total expenditures in the human sciences are expected to reach $579 million in 1982/83, a cumulative increase of 40.7% since 1978/79.

R & D expenditures in the human sciences will total $130 million in 1982/83, up from $110 million in 1981/82. RSA expenditures will be down to $449

Table 2.8

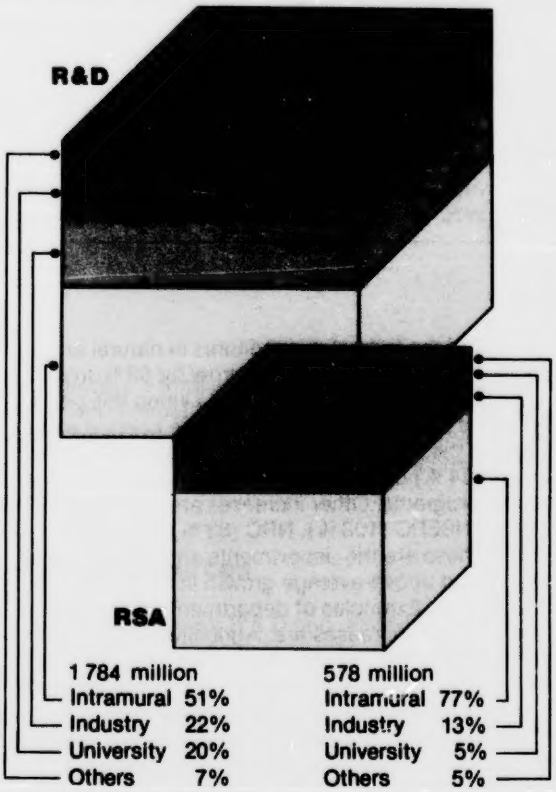
Growth in Granting Council Budgets

	1979/80	1980/81	1981/82	1982/83	Three Year Cumulative Increase
		(millions of dollars)			(%)
Medical Research Council	70	82	100	113	61
Natural Science and Engineering Research Council	121	163	202	227	88
Total	**191**	**245**	**302**	**340**	**78**

million from $470 million for the same period reflecting, in part, the decrease in Statistics Canada's budget by $43 million, coincident with the completion of the 1981 Decennial Census.

2.4

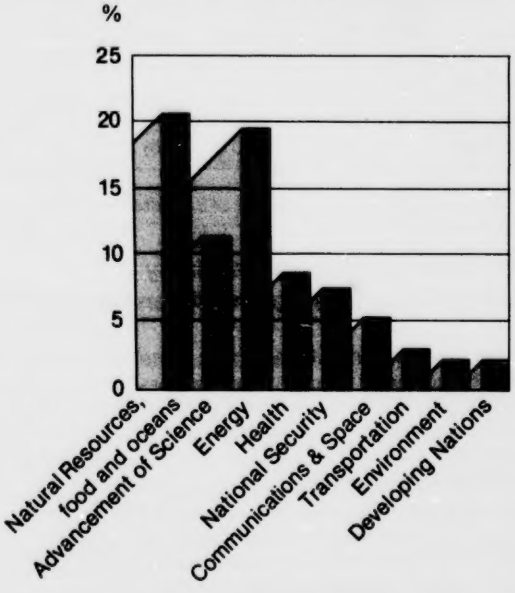
Federal Expenditures in the Natural Sciences by Performer (1982/83)



The distribution of expenditures on human sciences among performers in 1982-83 is compared with the distribution in 1978-79 in Chart 2.6.

2.5

Federal R&D Expenditures in the Natural Sciences — 1982/83 — by Application Area



The primary funder of extramural research in the human sciences is the Social Sciences and Humanities Research Council (SSHRC). SSHRC received a three-year cumulative budget increase of 55% from $36.6 million in 1979/80 to $46.6 million in 1981/82 reaching $56.7 million in 1982/83.

Over the past five years the distribution of intramural and total extramural expenditures for both R & D and RSA activities in the human sciences has remained fairly stable. However, within the extramural expenditures, the university sector's share of R & D has increased from 26% in 1978/79 to 33% in 1982/83 (Table 2.9).

Table 2.9

Federal R&D and RSA Expenditures in the Human Sciences by Performing Sector

	1978/79		1979/80		1980/81		1981/82		1982/83	
					(millions of dollars and (%))					
Total Human Sciences	**411.3**		**397.3**		**443.7**		**579.2**		**578.9**	
R&D Expenditures (Total)	**100.3**	**(100)**	**90.7**	**(100)**	**95.1**	**(100)**	**109.5**	**(100)**	**130.4**	**(100)**
Intramural	42.2	(42)	36.4	(40)	39.8	(42)	47.2	(43)	55.3	(42)
Extramural (Total)	58.1	(58)	54.3	(60)	55.3	(58)	62.3	(57)	75.1	(58)
Industry	4.9	(5)	4.7	(5)	3.3	(3)	4.6	(4)	5.0	(4)
University	26.0	(26)	26.9	(30)	30.5	(32)	34.6	(32)	42.4	(33)
Others	27.2	(27)	22.8	(25)	21.5	(23)	23.1	(21)	27.7	(21)
RSA Expenditures (Total)	**311.1**	**(100)**	**306.6**	**(100)**	**348.6**	**(100)**	**469.7**	**(100)**	**448.5**	**(100)**
Intramural	266.6	(86)	264.7	(86)	303.7	(87)	418.3	(89)	392.5	(88)
Extramural (Total)	44.5	(14)	41.8	(14)	44.9	(13)	51.4	(11)	56.0	(12)
Industry	9.6	(3)	9.6	(3)	10.2	(3)	12.0	(3)	13.9	(3)
University	14.9	(5)	13.6	(4)	15.5	(4)	17.7	(4)	19.3	(4)
Others	20.0	(6)	18.6	(7)	19.2	(6)	21.7	(4)	22.7	(5)

Total Science Expenditures by Federal Departments and Agencies

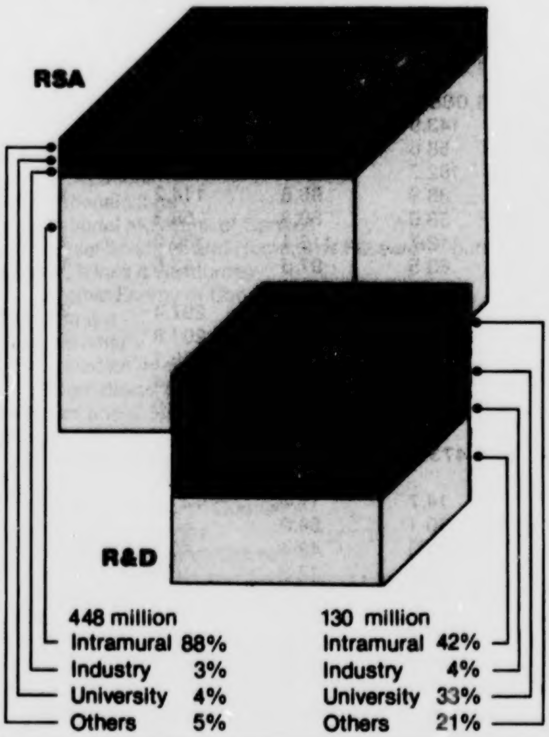
The federal government's scientific expenditures fall within the scope of four major envelopes. The largest group of science-based departments falls within the scope of the Regional and Economic Development Envelope which collectively accounts for nearly 60% of the 1982/83 science expenditures (Chart 2.7), followed by Social Development (24%), External and Defence and Services to Government (about 8% each).

Over sixty departments and agencies fund or perform R & D and RSA activities in natural and human sciences. Five major organizations responsible for approximately half of the expenditures are the Departments of Environment (DOE); Energy, Mines and Resources (EMR); Agriculture (AGR); the National Research Council (NRC) and the Natural Science and Engineering Research Council (NSERC).

The total of the federal expenditures in natural and human sciences is expected to grow by 63% from 1978/79 to 1982/83 (Table 2.10). During this period the largest increase has occured in the science expenditures of the Department of Industry, Trade and Commerce (184%) due to large increases in the industry support programs. Other increases are as follows: EMR (125%), NSERC (103%), NRC (83%), and MRC (76%). These are the departments and agencies that experienced above-average growth in their science expenditures. Examples of departments that received below-average increases are: Agriculture (54%), Atomic Energy of Canada Ltd. (43%), National Health and Welfare (40%), Statistics Canada (41%), Fisheries and Oceans (20%) and the National Museums (13%). Transport Canada's science expenditures decreased by about 43%. SSHRC received a 63% increase in its budget. Although the Department of

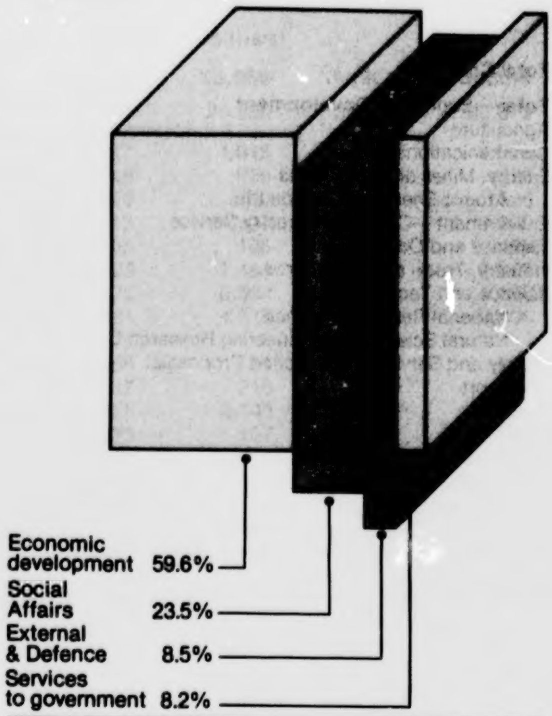
2.6

Federal Expenditures in the Human Sciences by Performer — 1982/83.



2.7

Federal Science Expenditures by Envelope — 1982/83.



Environment's total science expenditures increased by 62%, approximately the same as the average for all departments, the science expenditures of the Forestry Services component of the department increased by 130%.

Human Resources

Human resources for R & D and related science activities in federal departments and agencies remained relatively stable for the five years before 1982/83 (Table 2.11). The budgeted total person-years of 34,300 is only about 1,200 person-years over the 1980/81 total. This modest increase of 3.5% in two years reflects the government's policy to restrain growth in the Public Service. The considerably higher increase in science expenditures between 1978/79 and 1982/83 compared to person-years, reflects the government's policy of "contracting-out" science activities and the re-direction of funds to encourage industry and university R & D.

Noteworthy increases in human resources between 1981/82 and 1982/83 are: 125 person-years for the Department of Energy, Mines and Resources, 117 person-years for the Department of Fisheries and Oceans, 93 person-years for the National Research Council, 103 person-years for Atomic Energy of Canada Ltd., and 44 person-years for the Department of Communications. Major decreases are 913 person-years in Statistics Canada as a result of the completion of the 1981 Census of Population and Housing and 153 person-years in Agriculture Canada.

Table 2.10

Federal Expenditures on Activities in the Natural and Human Sciences, by Cabinet Committee

Department	1978/79	1979/80	1980/81	1981/82	1982/83
			(millions of dollars)		
Total Science	**1,809.0**	**1,891.8**	**2,121.2**	**2,604.6**	**2,941.5**
Total—Economic Development	**1,019.9**	**1,088.5**	**1,221.3**	**1,511.2**	**1,754.7**
Agriculture	127.2	143.9	152.4	168.5	196.1
Communications	61.9	58.6	65.3	81.3	66.7
Energy, Mines and Resources	124.5	162.7	179.1	229.7	280.5
Atomic Energy of Canada Ltd.	92.0	88.9	96.8	114.2	132.4
Environment—Canadian Forestry Service	29.8	39.8	50.3	58.3	69.4
Fisheries and Oceans	122.5	112.7	116.4	130.0	145.8
Industry, Trade and Commerce	61.4	83.5	97.5	143.5	173.3
Science and Technology					
National Research Council	197.2	201.4	226.1	297.4	360.7
Natural Sciences & Engineering Research Council	111.9	121.0	162.9	201.8	227.1
Supply and Services (Unsolicited Proposals)	12.4	14.9	15.0	15.1	15.1
Transport	42.1	27.7	17.2	21.4	24.0
Others	37.0	33.4	42.3	50.0	63.6
Total—Social Development	**454.0**	**473.0**	**526.9**	**604.4**	**693.4**
Communications					
National Library	13.1	14.7	17.2	21.6	25.8
National Museums of Canada	55.1	50.1	54.0	58.7	61.8
Social Sciences & Humanities Research Council	34.6	36.6	42.4	46.6	56.7
Employment and Immigration	10.0	16.0	17.3	18.9	18.3
Environment (except Canadian Forestry Service)	176.6	180.3	196.9	220.7	264.7
National Health and Welfare	58.2	58.0	63.8	72.6	80.9
Medical Research Council	64.2	70.1	82.0	100.2	112.9
Others	42.2	47.2	53.3	65.1	72.3
Total—External Affairs and Defence	**160.5**	**166.1**	**187.1**	**207.9**	**251.4**
External Affairs					
Canadian International Development Agency	35.6	37.4	36.5	40.4	45.0
International Development Research Centre	36.7	36.5	39.8	46.0	56.6
National Defence	83.3	87.1	102.6	112.0	139.6
Others	4.9	5.1	8.2	9.5	10.2
Total—Services to Government	**174.7**	**163.7**	**185.9**	**281.1**	**242.0**
Supply and Services					
Statistics Canada	133.3	122.2	144.1	230.0	187.2
Treasury Board	10.5	10.0	10.7	12.9	15.4
Others	30.9	31.5	31.1	38.2	39.4

Table 2.11

Person-Years Devoted to Activities in the Natural and Human Sciences, by Major Departments

Department	1978/79	1979/80	1980/81	1981/82	1982/83
			(person-years)		
Total Science	**34,035**	**33,124**	**33,088**	**34,953**	**34,296**
Total, Major Departments	30,590	29,723	29,855	31,325	30,873
Agriculture	4,168	4,057	4,018	4,179	4,026
Communications	644	649	670	689	733
National Library	494	500	500	517	526
National Museums of Canada	1,026	1,013	1,006	975	1,000
Social Sciences and Humanities Research Council	98	105	105	105	105
Energy, Mines & Resources	2,458	2,403	2,484	2,467	2,592
Atomic Energy of Canada Ltd.	2,363	2,322	2,394	2,512	2,615
Environment	4,989	4,921	4,915	4,924	4,936
External Affairs					
Canadian International Development Agency	56	56	57	57	57
International Development Research Centre	217	217	218	239	264
Fisheries and Oceans	2,423	2,122	2,143	2,273	2,390
Industry, Trade & Commerce	170	275	167	167	181
National Defence	1,909	1,895	1,870	1,877	1,878
National Health & Welfare	1,099	1,186	1,334	1,398	1,437
Medical Research Council	40	40	39	39	39
Science & Technology					
National Research Council	3,083	3,160	3,158	3,248	3,341
Natural Sciences and Engineering Research Council	59	61	75	81	98
Supply and Services					
Statistics Canada	5,111	4,534	4,619	5,489	4,576
Transport	183	207	83	89	79
Others	3,618	3,401	3,233	3,628	3,423

3. Major Applications

Introduction

Scientific activities are carried out by departments not only to support the attainment of their particular objectives, but also in support of broader governmental concerns, objectives and policies in some cross-departmental fields referred to as application areas. To assist in policy development and in related decisions, science expenditure data for a set of such cross-departmental application areas have been collected for some years.

Table 3.1 summarizes federal science expenditures within the major application areas selected for discussion in this section. Descriptions of the *kinds* of S & T activities being funded by the government are high-

Table 3.1

Federal Science Expenditures in Selected Application Areas

	1980/81		1981/82		1982/83	
Application Area	S&T*	R&D*	S&T	R&D	S&T	R&D
			(millions of dollars)			
Communications	46.3	34.8	56.4	44.8	52.2	39.7
Domestic Security	10.0	2.5	14.3	3.3	15.7	2.6
Energy	233.7	199.7	306.8	268.5	383.4	338.2
Environmental Issues	57.7	29.8	63.9	34.2	71.9	38.5
Food	199.9	164.1	237.4	190.5	263.2	209.0
Health	159.6	117.4	188.7	141.3	212.2	157.8
National Security**	109.2	103.5	120.2	112.9	148.3	140.0
Natural Resources	129.6	90.5	149.3	107.2	177.2	132.1
Oceans	57.0	27.4	60.6	29.5	73.4	31.6
Scientific and Technical Information***	143.4	—	166.2	—	196.1	—
Social Development	35.2	—	40.1	—	42.6	—
Space	59.0	58.4	64.1	63.5	56.6	55.7
Transportation	67.5	38.3	73.1	43.5	83.2	53.1

* In this and subsequent tables in this section, S&T refers to the sum of R&D and RSA (Related Scientific Activities) in both the Natural and Human Sciences, R&D refers to R&D in the Natural Sciences only.

** 1982/83 S&T expenditures in this area by the Department of National Defence also contribute directly to advancement in other areas, as follows: Communications, $4.7 million; Energy, $1.7 million; Health, $6.4 million; Oceans, $5.3 million; Space, $6.7 million; Transportation, $11.3 million.

*** By definition, Scientific and Technical Information is a Related Scientific Activity but is included in the discussion of Application Areas because of its importance and occurrence in many departments and agencies.

lighted in this section. In contrast, the Major Participants section highlights the organization of departments and agencies and the Budgetary Programs within which they conduct their S & T activities.

The data provided in the tables in this section refer to the foremost or *primary* application of the expenditures. For example, the primary application of the S & T expenditures of the Department of National Defence are in the area of *national security*. Nevertheless, portions of the department's science expenditures contribute simultaneously to advances in the areas of communications, science, transportation, oceans, space technology, and so forth. Similarly, S & T expenditures by the Canadian International Development Agency are made primarily in the *developing nations* application area. Nevertheless many of the agency's projects contribute to advances in other application areas as well. Examples of some *secondary applications* of this kind are noted in the text; in some cases data are provided in footnotes.

Communications

Since orderly development of Canadian communications is the responsibility of the Department of Communications, the majority of the government's expenditures related to this topic occur in this department, as shown in Table 3.2. As a specific subject area within its Strategic Grants program, the Natural Sciences and Engineering Research Council has allotted $3.8 million for communications research in 1982/83. Other agencies playing a role in communications science are the National Research Council, the Department of Supply and Services (Unsolicited Proposals) and the Canadian Radio-Television and Telecommunications Commission. The Department of National Defence, as part of its defence-related scientific activities, will also spent $4.7 million in 1982/83 on communications S & T.

Canada's vast size and thinly-spread population has made a large communication system an integral part of the nation. Even though Canada has one of the most advanced communications systems in the world, the search for better and less costly means of transmission continues. Canada is a leader in the development of reliable, efficient, high frequency sources and amplifiers, as well as carrier systems employing wire, multiconductor cable, coaxial cable, fibre optics and radio transmissions. The development of space technology in the 1960's revealed additional possibilities for long distance telecommunications. Satellites are proving to be economically practicable repeater stations, and they are also proving to be a feasible means of providing reliable low cost communications throughout Canada, and especially to far northern communities.

Telidon takes the form of an interactive TV system allowing users to retrieve information stored in a computer data base by means of a keyboard and a modi-

Table 3.2

Federal Science Expenditures in Communications

Department/Agency*	1980/81 S&T	1980/81 R&D	1981/82 S&T	1981/82 R&D	1982/83 S&T	1982/83 R&D
	(millions of dollars)					
Total	**46.3**	**34.8**	**56.4**	**44.8**	**52.2**	**39.7**
Canadian Broadcasting Corporation	3.6	—	4.0	—	4.6	—
Communications	28.6	23.8	42.4	37.2	37.3	31.9
National Research Council	4.6	4.6	3.3	3.3	2.6	2.6
Natural Sciences and Engineering Research Council	2.1	2.1	3.0	3.0	3.8	3.8
Supply and Services (Unsolicited Proposals)	5.2	4.2	1.5	1.2	1.5	1.2
Others	2.2	0.1	2.2	0.1	2.4	0.2

* Directly-related S&T expenditures by other departments and agencies in 1982/83: National Defence, $4.7 million.

fied TV set. Information may be in textual, graphic or photographic form. The technology has been designed to permit data to be retrieved "off-air" from regular or special TV broadcasts, from central computers via phone lines, coaxial cables or fibre optics cables and to permit user-to-user communication for homes and offices in applications such as electronic mail, electronic banking and teleconferencing. It has also been designed to be immune to component obsolescence resulting from such things as improvements in television receivers, in transmission media and in data base and storage techniques.

Since the department announced the development of Telidon in August 1978, significant advances have taken place both in development of the technology and in its demonstration. The first use of Telidon to receive signals off-air was announced on February 1, 1980. In this trial, 35 "pages" of Telidon text and graphics are being continuously broadcast by TV Ontario. The coded information is contained in the portion of the transmitted TV signal which appears as a horizontal black line just outside the normal picture. Accordingly, no phone lines or cable connections are required for this *Teletext* mode of operation. In contrast, *Videotex* is the generic name for systems which use telephone lines and/ or cables to enable the user to interact directly with the computer storing the data. A number of trials of this mode of Telidon use were initiated in 1979.

Subsequently, Telidon was selected for the first United States consumer trial of teletext, conducted at Station WETA in Washington, D.C., starting late 1980. A second foreign sale was made to the Presidential Central Office of Statistics and Informatics of Venezuela. Here, Telidon is to be used in the videotext mode to provide government information to "store-front" locations.

Two Canadian videotext pilot projects using Telidon have been initiated: the Manitoba Telephone System's Project IDA and the installation of Telidon in several government service bureaux as well as in a number of public places across Canada early in 1981, for use in responding to the inquiries by citizens about government information. Project IDA is a pilot study in which 100 homes in South Headingly, Manitoba, are being provided with advanced communications services such as videotex, fire and burglar alarm services, remote metering and medic alert services. The department is supplying about 40 Telidon terminals for this project.

In December 1980, Telidon technology was officially ratified as one of the world standards for videotex by the agency of the United Nations responsible for setting worldwide telecommunication standards. This achieved one of the prime objectives of the government, which was to ensure that Telidon could be marketed around the world.

Complementing activities related to the development of Telidon is a federal contribution of $1.2 million towards development of what could be Canada's most sophisticated multi-service two-way cable TV system. The prime mover behind the four-year, $4.5-million program is Télécable Videotron, a major cable TV firm in the Montreal area. With government backing, and along with a number of other participants, the firm will develop a pilot system capable of providing new services such as videotex, fire, burglar or medical alarm monitoring and home video games. A major component of the project is a 250-terminal field trial of Telidon. A key thrust of the exploitation strategy is to maximize Canadian content delivered to Canadian homes via Telidon by encouraging the rapid growth of Canadian commercial information sources.

In recent years, automation (in the form of free-standing text editing and automatic word processors) has been making rapid inroads into the office environment. At the same time, new data communications services have led to the creation of computer communications networks which permit wide-spread access to data processing and information services of all kinds. These two technologies, data communications and automatic word processing, are now being combined to make possible automated offices, or "offices-of-the-future", involving electronic office-to-office communications, information storage and retrieval, and sophisticated information management tools. As a result, it is expected that there will be large-scale office automation in the immediate future. Canada, with a leading position in both the data communications and word processing industries, has an excellent opportunity to play a major role in office automation.

Under the leadership of the department, a joint government-industry Office Communications Systems program has been initiated to establish Canadian industrial leadership in certain communications-related aspects of the office-of-the-future through the development of nationally-manufactured equipment to implement Canadian network services. The government has reserved $12.5 million for direct support of this program. Details are discussed in the Extramural-Industry section.

On the industry side, the strategy is to develop an adequate capital base for growth through direct involvement of several Canadian companies in a consortium of equipment and service suppliers. On the government side several departments are involved. For example, the industrial aid programs of the Department of Industry, Trade and Commerce are available to assist in the development of Canadian hardware and software products and in the establishment of Canadian manufacturing capability. The Department of Communication's specific role in the program is the development of a "systems" capability, in which a range of compatible products operating in a network environment can solve office communications problems for both domestic and foreign users. The objectives of the department's activities in this program are:

- to ensure operating compatibility of Canadian products in both national and international network environments;
- to foster the development of a suitable industrial infrastructure in the office communication systems field;
- to plan and manage field trials of Canadian-made products and services in order to accelerate development, optimize performance and demonstrate Canadian capabilities.

Canada has been in the forefront in network development. The department's participation in international bodies such as the International Telegram and Telephone Consultative Committee and the International Standards Organization are included in the Network R & D program, to ensure that Canadian interests in communications services, network and equipment standards are adequately protected. In order to deal with standardization issues at the national and international level, priority is given to the study of digital networks and network protocols.

The efficient exploitation of the radio-frequency spectrum is a statutory responsibility of the federal government, i.e., the Department of Communications. To discharge this responsibility effectively, research is required on the propagation of radio waves, natural and man-made sources of unwanted radio emissions or interference, and the development of techniques for more extensive use of the available spectral regions. A substantial portion of the research resources are dedicated to work in support of policy and regulatory priorities. An extensive study of electromagnetic propagation in the Great Lakes area was initiated to provide technical data required for policy development and planning for broadcasting and land mobile services. Considerable research effort has also been deployed in developing the automated spectrum management system, mainly for determining spectrum usage and for spectrum surveillance.

In addition to addressing research problems of departmental and national concern, the program has also provided extensive input to the work of the International Telecommunications Union. Much of this has appeared in the recommendations and reports of the International Radio Consultative Committee or in the deliberations of World Administrative Radio Conferences.

Mobile radio systems serving users on land, water and in the air operate on frequencies assigned by the department under the Radio Act. The department has a number of activities in progress, ranging from planning for a satellite to serve air and marine and some land mobile users to development of mobile digital radio systems.

Domestic Security

The expenditures in the application area, domestic security, are concerned with scientific activities related to the protection of the lives and property of the citizens of Canada. The expenditures for such activities are shown in Table 3.3. The activities themselves are mainly concerned with improving the effectiveness and fairness of the criminal justice system, aiding in the reduction of the social and economic costs of crime and of the criminal justice system and increasing public understanding and support for crime prevention and control efforts. Some initiatives, generally undertaken in cooperation with provinces, are directed towards making improvements in civil justice.

The constitution creates a division of responsibilities in the administration of justice between the provinces and the federal government. In this regard, the Department of Justice has as one of its responsibilities the review of administrative and legal policy issues at the federal and provincial levels. The public, Parliament and various priority-setting reviews have stressed the need to identify and remedy deficiencies and anom-

Table 3.3
Federal Science Expenditures for Domestic Security

Department/Agency	1980/81 S&T	1980/81 R&D*	1981/82 S&T	1981/82 R&D	1982/83 S&T	1982/83 R&D
	(millions of dollars)					
Total	**10.0**	**2.5**	**14.3**	**3.3**	**15.7**	**2.6**
Justice	2.7	—	3.9	—	6.0	—
Law Reform Commission	1.5	—	2.3	—	2.9	—
Solicitor General	3.1	—	4.6	—	4.1	—
Others	2.7	2.5	3.5	3.3	2.7	2.6

* R&D refers to R&D in the Natural Sciences only.

alies in the law and the legal system. Within the department much of the requisite work falls to the Policy Planning and Development Branch which has as one of its objectives "to promote the development of laws and a legal system that are sensitive and responsive to the needs of the citizens and are more intelligible and accessible to the public". In support of this objective, the following kinds of activities are involved:

- development of a decision-making framework and background analyses for developing departmental objectives and policies;
- perceptive evaluation of emerging issues concerning the law and legal system that can be expected to require policy responses;
- the identification of research needs and the promotion of a research capacity as an aid to: (i) law reform; (ii) the identification of anomalies and inconsistency in the law; and (iii) the evaluation of the operation of the legal system;
- background studies on policy issues to expose, question and clarify basic assumptions that underly policy concerns;
- undertaking legal and empirical studies;
- integration of program objectives, output measures and evaluation mechanisms into new policy initiatives and ongoing program commitments;
- the collection and development of statistics required for the development and evaluation of legal policies, programmes and experimental projects.

A wide range of projects is carried out, grouped into three main categories. The first is policy-directed research, which is intended to provide a valid and reliable base of social and legal information for the development of policy options in such areas as: the victims of crime; the management of witnesses; family violence; sexual offences against adults and children; drugs and crime; human experimentation; consanguinity and affinity; sentencing; homicide and assault; arrest and seizure; the general part of the criminal law; pre-trial discovery and disclosures; Unified Family Courts; family law; administrative law; the Federal Court; commissions of enquiry and judicial review; and representations in the public interest.

The second category of projects is concerned with policy development and coordination. The projects arise from a wide variety of sources, with varying time frames and priorities. Some examples are: child abduction and abuse; courts policing; criminal justice policy; the federal role in law enforcement and prosecution.

The third category differs to some extent from the first two in that the projects emanate from outside the department. They arise from reports rendered by the Law Reform Commission of Canada. The subjects cover numerous topics: sexual offences, mental disorder, diversion, evidence, marriage, divorce and maintenance, criminal responsibility, contempt, the jury, homicide and assault, arrest and seizure, the general part of criminal law, discovery, Unified Family Courts, administrative law, the Federal Courts, commissions of enquiry and judicial review, and representations in the public interest.

The Evaluation and Statistics Unit within the Department of justice undertakes social science research in support of justice policies and departmental resource allocation. This research includes evaluation of ongoing programmes, evaluation of existing legislation policy, evaluation of proposed programs and policies, and exploratory research in anticipation of new policy directions. For example, the following justice programs, which are cost-shared with the provinces, are being evaluated: the legal aid program, the native courtworker program, and compensation to victims of violent crime. These evaluations are performed on a cyclical basis across the country and involve detailed studies of policy, administrative structure, social impact, and legislative implications.

In addition, work is underway in support of future policies in the area of family law, including the evaluation of experimental unified family courts, the evaluation of various projects concerning pre-trial disclosure or evidence, the evaluation of various projects concerned with experimental diversion from the criminal justice system, the evaluation of various experiments in public legal education, the evaluation of innovations in sentencing, and the evaluation of innovative approaches to the provision of legal services. Each of these projects involves studies of existing procedures which have the promise of providing new directions for policy for the justice system as a whole or studies which have been designed to answer specific questions relating to issues soon to be addressed within the justice system. While the research is applied, in the sense that its objective is to answer specific policy questions, it is based upon general theories of public administration, jurisprudence, and sociology and it draws upon the methodologies common in the human sciences generally. The department does not, as a rule, support any research the genesis of which is a theoretical question, but encourages applied research which is informed by a full recognition of the fundamental theoretical issues at stake. Unsolicited proposals are considered but the majority of the work performed is contracted out after specific information needs have been articulated with the department. However, research organizations and academic institutions interested in the social impact of justice policy are invited to make their interests known to the department.

All of the activities of the Law Reform Commission of Canada are classified as human sciences. The objective of the commission, as defined by the Law Reform Commission Act is "... to study and keep under review on a continuing and systematic basis the statutes and other laws comprising the laws of Canada with a view to making recommendations for their improvement and reform ...".

Under the administration law project the commission prepares for and participates in conferences and discussions with regulatory agencies concerning such subjects as confidentiality and release of information, regulations and sanctions, and liaison among federal and provincial agencies, law faculties and international law associations. A subject of particular interest now under examination is the application of sanctions by various administrative agencies whose practices appear to differ widely.

Another project, Protection of Life, deals with such matters as criteria for determination of death, behaviour modification, cessation of treatment and the concept of a person in law. The nature of this research and the sources of expertise are somewhat different from those otherwise concerned with criminal law but ultimately, the findings will be combined with other recommendations for reform in criminal law.

Within the Ministry of the Solicitor General, scientific activities in the human sciences are concentrated within three divisions of the Programs Branch—Research, Statistics and Planning and Liaison. The program of the Research Division is designed to respond to policy and program issues in criminal justice. Research is carried out to assist in policy and program development and to evaluate new legislation and programs. Because the divison's work is closely integrated with policy development and evaluation, specific projects are designed in close consultation with the primary users of the information. Most of the research is performed extramurally under contract with universities and private consultants. The activities of the Research Division are divided between four general areas: prevention of crime and victim assistance; research related to criminal justice policy; police research; and corrections research.

The Causes and Prevention Research section is responsible for studies dealing with the planning and evaluation of crime prevention and victim assistance policies and programs. Examples of these studies include the evaluation of Canada's new gun control laws, studies on family violence, evaluations of police programs to assist victims, and a victimization survey.

Criminal Justice Policy Research focusses on the evaluation of the forthcoming legislation on young offenders, public attitudes, community participation, and expectations and satisfaction vis-à-vis police services. The section also carries out research relating to such fundamental issues as sentencing effectiveness and decision making in the criminal justice system, as well as studies relating to the effectiveness, efficiency, and equity of new policy initiatives such as diversion and community-based sentencing alternatives.

The research activities of the Police Research section are directed toward the development of police policy and practices which would increase the efficiency, effectiveness, and public acceptability of police services. Within this framework individual projects are being undertaken in areas such as native policing, police officer and public safety, women in policing, police productivity, police accountability, traffic law enforcement, and crisis intervention.

The Corrections Research section is concentrating its activities on the policy and program issues related to correctional effectiveness, conditional release, prison violence, and long-term imprisonment. The section is also studying the determinants of penitentiary populations, and carrying out a major historical study of the Canadian Corrections Service.

The Statistics Division provides specific statistics or analytical reports in response to ministry needs, such as the provision of a quantitative base for proposed revisions to the Cannabis and Young Offenders Legislation. It also provides specialist services in the fields of statistical methodology, computer technology and information systems development. The division's other major objective is to promote an environment of liaison and co-operation within the national criminal justice statistics community. To this end, the division has contributed to the work of federal-provincial committees whose main purpose has been the planning and implementation of the new national justice statistics agency described in the section dealing with Statistics Canada.

The objectives of the Planning and Liaison Division include:

- ensuring that relevant, high quality criminal justice research, statistics, and other empirical findings and knowledge are understood and disseminated to federal, provincial and municipal departments and agencies, the private sector, the research community and the general public, who are working in or concerned about crime and the criminal justice system. This is done through two programs: a multi-faceted publications program; and a program of workshops, seminars and courses;
- encouraging, through the ministry's CRIMDOC Centre, the timely exchange of information and providing library reference and referral services to its clients within the ministry, as well as to other users in Canada and abroad.

The Royal Canadian Mounted Police have been actively engaged in numerous related scientific activities, as well as applied and experimental research. Though much of the R & D is conducted internally, the Ministry of the Solicitor General's Research Division provides valuable assistance in performing many of the human sciences research requirements.

The areas of research in which the Force is involved are highly diverse and multi-faceted. Some examples are: policing standards; family dynamics e.g., crisis intervention, child abuse, interspousal violence, sexual assault, etc.; vandalism; subliminal advertising; crime prevention through environmental design; senior citizen/victimization programs; commercial crime e.g., fraud, computer crime; traffic law enforcement; police productivity e.g., shift scheduling; native policing; police management e.g., training and personnel development; police-community relations; gun control; electronic and specialized equipment used for law enforcement e.g., voice identification, polygraphs, surveillance equipment, computers; forensic sciences e.g., toxicology, alcohol, drugs, document examination, hair & fibre chemistry, serology, radiography, firearms; fingerprints; physical, data processing and technical security; explosives disposal technology.

In 1979, the Force assumed the lead-agency role for a program of Science and Technology in Support of Law Enforcement, with responsibility for financing, contracting and monitoring of all work carried out under the program, from project definition through to completion. The S & T requirements under the program are based on needs identified in an annual submission from the Operational Research Committee of the Canadian Association of Chiefs of Police. Some examples of such projects are: development of a Canadian-made bomb suit, development of a protective head-gear information package, saliva monitoring for drugs, more effective tear gas and specialized imaging systems, latent fingerprint detection, soft body armour, occupational health and safety.

Energy

As in many other countries the importance of energy concerns in Canada is reflected in the government's expenditures for energy S & T. Since 1976/77 the expenditures have grown at an annual average rate of about 20%, and as shown in Table 3:7, now lead by a significant margin S & T expenditures in any other application area. All energy-related S & T expenditures by department and agency are shown in Table 3.4. For those interested in or concerned with programming and budgeting, these expenditures are established by means of several distinct mechanisms.

Program Structure and Funding

The major portion of energy S & T activities is reviewed by the Inter-departmental Panel on Energy R & D. Established in 1975, the panel has recommended each year a priority-ranked and coordinated government program of energy S & T support, based on its analysis of the opportunities and problems associated with the various energy delivery systems available to Canada, and on its annual review of the activities of the departments and agencies participating in the work of the panel. As a consequence, for most years since 1976/77, additional i.e. *incremental* funds have been provided to initiate new activities or to supplement the S & T activities carried out by departments and agencies with departmental funds, i.e. those allocated through the usual budgetary processes. The incremental funds will total $46.6 million in 1982/83. The departmental funds for activities reviewed by the panel are estimated to be $154.2 million in 1982/83.

The panel was also assigned responsibility for planning and programming of the energy R & D activities for which the National Energy Plan has provided $260 million in the period 1980-1983. New or increased activities totalling $35.0 million were funded in 1981/82 from this allotment and it is estimated that $75.0 million will be spent in 1982/83 to support on-going activities and also to initiate some new projects. These activities are further discussed below.

In addition to the funds for energy R & D assigned to the Panel on Energy R & D, the National Energy Plan also provides for other energy S & T activities: $4 million over four years for special support for coal R & D in the Atlantic provinces, $50 million for a 5-year program with Saskatchewan on heavy oil R & D, $50 million over the period 1980 to 1983 for the development of new technologies for using coal, especially fluidized-bed combustion, with the possible further provision of $100 million during 1984-85.

For administrative and budgetary reasons, not all of the government expenditures on energy S & T are

Table 3.4

Federal Science Expenditures in Energy

Department/Agency*	1980/81		1981/82		1982/83	
	S&T	R&D	S&T	R&D	S&T	R&D
	(millions of dollars)					
Total	**233.7**	**199.7**	**306.8**	**268.5**	**383.4**	**338.2**
Agriculture	0.2	0.2	2.0	2.0	4.2	4.2
Energy, Mines and Resources (Total)	82.6	78.2	116.2	111.4	144.1	138.7
Mineral and Earth Science Services Program	34.1	32.4	45.9	45.7	62.6	63.6
Energy Program	48.5	45.9	70.3	65.8	81.6	75.2
Atomic Energy of Canada Ltd.	90.6	72.7	108.4	90.4	125.7	103.8
Environment (Total)	5.4	4.9	7.3	6.7	8.2	7.6
Canadian Forestry Service	4.4	3.9	6.2	5.7	7.0	6.6
Fisheries and Oceans	7.8	4.1	8.3	4.4	9.8	4.7
Industry, Trade and Commerce	0.6	0.6	1.5	1.5	7.1	7.1
National Research Council	30.0	28.5	44.8	42.2	62.2	58.8
Natural Sciences and Engineering Research Council	6.2	6.2	6.6	6.6	8.2	8.2
Public Works	5.3	2.8	4.6	0.7	5.3	1.5
Transport	1.1	0.3	1.9	0.6	2.4	0.7
Others	3.9	1.2	5.2	2.0	6.2	2.9

* Directly-related S&T expenditures by other departments and agencies in 1982/83: National Defence, $1.7 million.

included in the scope of the advisory responsibilities of the Panel on Energy R & D. The following are generally excluded:

- fundamental research funded by the granting councils;
- socio-economic studies;
- health and safety studies;
- federal-provincial joint projects;
- large-scale participation in new technologies at the demonstration or early commercial level (e.g., the Syncrude project);
- resource assessments;
- environmental studies concerned with the effects caused by energy activities (development of technology to minimize such effects, however, would be included).

For example, there is the jointly-funded federal-provincial program of demonstration projects in renewable energy resources, with estimated federal expenditures in 1982/83 of $33.5 million and $5.0 million for the government's share of the joint program with the Province of Saskatchewan to develop technology for heavy oil recovery. An expanded program to study the impact of energy development on the Arctic marine environment by Environment Canada, the Department of Fisheries and Oceans and Transport Canada will involve 1982/83 expenditures estimated to be $6.0 million. The Natural Sciences and Engineering Research Council has reserved $8.2 million for funding research proposals directly related to energy under its Strategic Grants program. Since some of the new energy developments are likely to have significant impact on water resources, an Environment Canada study has initiated a study to provide an assessment, in quantified terms to the extent possible, of water supply constraints to energy development. The environmental impacts of thermal and nuclear power sites is also recognized as an important problem and research funds are committed to proceeding with Phase II of a Thermal Power Plant Siting Study aimed at producing comprehensive guidelines for future developments.

The Department of National Defence has an energy R & D program dealing with electrochemical battery technology and mobility fuels involving combustion and the fuel/engine interface. The fuel-related R & D is directly applicable to the National Energy Program objectives dealing with the efficiency of energy use. Work is under way to investigate the performance of gas turbine diesel engines and durability problems encountered when using lower quality fuels which may eventually be introduced to improve availability.

R&D Program Content and Status

Canada's current energy problem is a shortage of easily-accessible oil under its territorial control; it is well-endowed with other sources of energy. S & T activities under the National Energy Plan have been programmed on the basis of the following order of priorities, viz.,

- New liquid fuels, i.e. alternatives to the transportation fuels, notably gasoline. There are several possibilities; the challenge is to find the most promising fuels and to provide the necessary support for commercialization. S & T activities will provide information on technical feasibility, environmental acceptability and economic viability.
- Improved efficiency in energy use, i.e. energy conservation. Although not always completely risk-free, conservation is the cleanest, most enduring and in most situations, the cheapest way to reduce dependence on oil, thereby improving security of energy supply. Conservation S & T may improve efficiency of energy use in all sectors of the economy.
- New energy sources. The objective is to achieve a significantly greater role for new energy sources in the inevitable transition from the current reliance on oil and gas. A range of S & T activities will be pursued, from developing environmentally-acceptable coal technology to the use of hydrogen as an energy supply system.
- Conventional energy sources. Continuing support for S & T is required to improve oil and gas recoveries in existing production areas and to develop production technology to meet the severe conditions in the Arctic and off-shore regions as well as to continue the technological development needed to maintain a Canadian-based nuclear option.

Table 3.5 shows the funding distributions among these four areas for 1981/82 and that proposed for 1982/83. A brief description of the major thrusts follows:

New Liquid Fuels

Substitution for oil is of critical importance and is being attacked on two fronts; the development of alternatives to liquid hydrocarbons for transportation and the

Table 3.5

Energy R&D Funding under the National Energy Plan.

	1981/82	1982/83
	(millions of dollars)	
Total	**35.0**	**75.0**
New Liquid Fuels	11.2	18.8
Conservation	7.0	18.8
New Energy Sources	10.3	21.4
Conventional Energy Sources	6.2	8.3
Program Coordination	0.3	0.3

substitution of heating oil by other fuels such as natural gas and coal and uranium used to generate heat and/or electricity. Activities in relation to these latter fuels are considered below under Conventional Energy Sources.

The most promising hydrocarbon alternatives, in the short term, are propane, compressed natural gas (CNG) and alcohols (methanol and ethanol). In the longer term, they may be produced from synthetic crude oils either derived from coal, or as is currently done from tar sand bitumen.

Propane and compressed natural gas are at a more advanced stage of commercialization than the other alternative transport fuels. Funding has been provided for testing compressed natural gas in fleets of commercial vehicles. Only minor engine modifications appear to be required. Safety tests are being carried out on vehicle prototypes.

In 1981/82 over $11 million was allocated to new projects in the area of New Liquid Fuels. Such new projects included $2.5 million for the development of a small pilot plant for the co-processing of bitumen or heavy oil with coal in the presence of hydrogen. In wood gasification, $0.45 million was allocated for the testing of a pressurized fluidized-bed oxygen gasifier and for the development of pressurized wood gasification equipment. A $0.6 million program was mounted towards the use of compressed natural gas as an alternative transportation fuel, concerned with developing improved conversion kits, storage systems, fuelling technology, compressors, engine control technology and dispensing systems. Other projects involved process development and process demonstrations in the conversion of wood and coal to alcohols and synthetic gasolines, and engine testing and development for alcohol-fueled vehicles.

Since alcohol fuels are of proven value, R & D is focussed on reducing production costs. A program for producing synthesized gas from coal, lignite and wood is under development. The process, which can be used for methanol production, is nearing commercial feasibility. For ethanol, Agriculture Canada is developing fuels from agricultural feedstocks. A pilot plant for the conversion of cellulosic material to ethanol is now under study. The total system may involve bio-engineering of new organisms using gene-splicing techniques and the construction of process development units to optimize the performance of the system.

To meet Canada's growing need for "middle distillates", further R & D is being initiated on methods for producing such fuels from oil sands bitumen and coal. A hydrocracking process, developed by the Canada Centre for Mineral and Energy Technology, produces 10-15 percent higher distillate yields from tar sands bitumen than the conventional coking process. The new process is being further developed with the expectation of early commercialization. In recent work, progress was made in increasing the degree of desulphurization and in achieving higher yields at lower pressures. It is estimated that over $26 million will be spent in 1982/83 in the New Liquid Fuels Area. This includes almost $23 million in extensions to the 1981/82 projects and over $3 million in two new initiatives: $2.5 million for a major hydrogen and electrochemistry research program; and $0.7 million for investigating the environmental problems associated with new liquid fuels such as methanol.

Conservation

The potential contribution to energy self-sufficiency from increased efficiency of energy use is considerable. In 1981/82, $7 million of the R & D funds under the National Energy Plan was allocated to new projects in this area. One of the most promising areas is in the design of energy-efficient buildings. The emphasis in future will be to analyse the data obtained from monitoring prototype houses constructed in past years, and to evolve optimal design configurations incorporating improved construction standards, better insulation, and passive solar heating concepts, such as thermally-efficient windows and shutters. For existing buildings the main emphasis will be on retrofit improvements to oil and gas furnaces that can provide energy savings of at least 20 percent.

In the industry sector, effort is being directed to development of the potential for heat pumps, particularly types which can be manufactured as well as used in Canada. Increased funding is being provided for the Industrial Energy Research and Development Program, which responds to industry proposals for R & D assistance in improving energy efficiency in products, processes and services.

In the food supply sector new products included the development of energy efficient technologies in greenhouses, in crop drying and in the processing and preservation of food. In the transportation sector projects included the development of efficient engines and equipment capable of using a wide variety of fuels and technical support for the development of standards.

In 1982/83 almost $19 million will be spent on R & D projects in the Conservation area. This includes almost $14 million in extensions to the 1981/82 projects and almost $5 million in two new initiatives: $3 million to expand the cost-shared Industrial Energy R & D Program; and $1.6 million in an uncommitted reserve to be used to respond to emerging conservation projects.

New Energy Sources

Over $10 million was allocated in 1981/82 to new projects in this area. Among the first to be funded were two projects related to renewable or virtually "inexhaustible" energy resources:

- $1.8 million was provided to start a $35 million project (Aeolus) to design and construct a large scale wind turbine of the vertical axis or "egg-beater" design, developed by the National Research Council. With a design output of several megawatts it will be built by Canadian industry under contract to Hydro-Québec, which will share equally with the National Research Council both in its financing and in the provision of technical support for its development and evaluation. This huge wind turbine will be over 100 metres high and will supply power directly into the Hydro-Québec electrical grid.

- $2.3 million has been contributed in 1981/82 by the National Research Council to a joint project with the Government of Quebec, to construct an experimental fusion device (a Tokamak) and to conduct associated research on certain characteristics of the magnetic confinement approach to controlled fusion energy. A consortium of Hydro-Québec, two Montreal universities and two Montreal high technology companies will carry out the project. The estimated cost of the project over the first few years is about $36 million.

Other work on new energy sources includes a vertical axis water turbine, the photovoltaic conversion of solar energy to electricity, and development of active solar space heating systems. Some of this effort will have only long term pay-off. Domestic hot water systems, however, are expected to become commercially viable within a few years.

Wind Energy activities in the Department of the Environment include research and provision of support information for the design, siting and evaluation of wind energy conversion systems. In addition to the continued provision of raw wind data obtained through the Atmospheric Environment Service measurement network, research and development into vertical wind profile characteristics, the influence of topography and geography on wind fields, and analysis of wind energy potential will be expanded. Due to the variability of wind fields, the program will evolve to include investigations of regional and local wind characteristics as an aid to site selection and evaluation.

The Department of the Environment also has a solar energy program directed towards improving knowledge of those aspects of solar and terrestial radiation which are important to the solar energy utilization, and to provide and to make easily accessible data and information on all relevant atmospheric variables. The activity comprises data gathering, model development and the application of the data to support the exploitation of Canada's solar resource.

In biomass R & D, the National Research Council has evolved a promising new technique—the fixed film reactor—for anaerobic digestion of biomass media such as municipal sewage. The process involves bacterial action on a fixed support such as clay tile. It produces a greater volume of methane per tank volume as compared with a homogenous reactor. It is possible that the methane could be produced economically. "Scale-up" tests are proceeding and various feedstocks are being examined. Agriculture Canada is experimenting with energy crops and crop residues for biomass energy. Studies are also proceeding on the development of plantation machinery for short-rotation tree farming. The safety and performance of wood stoves is also being examined. Geothermal energy, the heat available below the surface of the earth, is being studied by the Earth Physics Branch of the Department of Energy, Mines and Resources. A joint federal-provincial study of the geothermal resource at Meager Mountain, B.C., has shown such promise that B.C. Hydro is planning a 50-megawatt steam-to-electrical energy generating station. Attention is now being turned to Mt. Cayley, also in British Columbia. Other areas under study are the sedimentary basins of the prairies and structures in the Atlantic provinces.

To encourage replacement of heating oil by coal, research is being carried out on a full-scale demonstration program of fluidized-bed combustion technology. Construction of the first unit is underway: commissioning of the first prototype unit is expected in 1982. In such systems, low-grade fuels can be utilized, such as coal with high sulphur content, wood wastes and garbage. Limestone added to the bed reacts with sulphur dioxide to form sulphates that remain in the bed, thus reducing atmospheric sulphur dioxide emissions by up to 90 percent.

Studies of heating oil substitution by nuclear power include a hybrid oil/electric heating experiment initiated in 1980/81 in the town of Deep River, Ontario, the development of a mini-reactor for district heating and various nuclear system assessments, such as the recently-completed assessment providing industrial process heat directly from the CANDU reactor in the Bruce Peninsula, Ontario.

The technology of extracting oil from the tar sands is of prime importance. Oil is currently separated from the sands by a hot water process which is inefficient when the sands have a high clay content due to the formation of a clay emulsion. The National Research Council has developed a new process, spherical agglomeration, which overcomes emulsion formation. A pilot plant test has been completed and scale-up to a 100 tons-per-day demonstration plant is planned. Federal funding is also contributing to the development of a cold water separation process and a feasibility study for a full-scale plant has been completed. Large amounts of energy, particularly in the form of high-pressure steam, are required for the in-situ production of oil from the tar sands. The possible role of nuclear reactors which could provide this energy on a competitive basis is being studied.

In 1982/83 over $21 million of the R & D funds provided under the National Energy Plan are being allocated to projects in New Energy Sources. This includes almost $20 million in extensions to the 1981/82 projects and $1.6 million in new initiatives: $0.4 million to develop environmental protection criteria and technologies associated with the use of oil sands and coal, $0.6 million to expand photovoltaics research and $0.6 million on nuclear fusion materials/engineering technology.

Conventional Energy Sources

Apart from the on-going commitment to nuclear power R & D, much of the government's support for S & T in conventional energy sources is concerned with oil and gas, and in particular to the special problems arising from the hostile environments of the Arctic (e.g., Beaufort Sea) and deep, off-shore drilling sites, such as Hibernia off the East Coast. In 1981/82 $6 million of the R & D funds under the National Energy Plan were allocated to projects in this area. Studies underway are concerned with:

- geotechnical and environmental guidelines for hydrocarbon exploration and production in Arctic and off-shore regions;
- exploration technologies for deep marine locations;
- cold climate materials and engineering processes;
- technologies for the safe transport of energy commodities especially on the North Atlantic and Arctic routes;
- environmental studies of such matters as CO_2 impact, water supply constraints and comparative energy supply strategies.

Also included was increased support for R & D under the aegis of the Canadian Electrical Association, directed to technical problems in utility operations and increased efficiency in electricity usage. Also, in the electrical field the National Research Council is supporting additional research on high voltage DC transmission of electricity, which is particularly effective over long distances.

Activities in the Conventional Energy Sources area will involve an estimated $8 million in 1982/83, including $0.6 million for a new initiative of joint industry-government projects to enhance light oil recovery at specific Canadian reservoirs. Also included is $0.6 million to expand off-shore marine research related to oil and gas development and production.

The Atmospheric Environment Service of the Department of the Environment is actively supporting energy exploration by working with such companies as Dome Petroleum, Panarctic, Petrocan, Esso Resources and Gulf Canada in the Beaufort Sea, Sverdrup Basin, Davis Strait and East Newfoundland. These activities relate to the ongoing day-to-day operations when special forecasts of ice, wind, wave and temperatures are provided on contract to optimize their exploratory drilling programs. They also relate to long-range questions concerning the development of environmentally-safe production systems.

With respect to the coordinated activities funded by departments with additional support from the *incremental* funds of the Energy R & D Panel, the policy has been to emphasize S & T activities related to renewable energy resources as a first priority followed by those related to energy conservation, while continuing support from the government aimed at maintaining the technological base for the CANDU nuclear system for electricity generation. Much, if not all, of this effort will be continued, both because the various federal-provincial demonstration initiatives underway require strong technical support and because the effort is congruent with and provides a base for the additional S & T initiatives under the National Energy Plan.

As mentioned above, the renewable energy resources has been one of the priority areas for incremental funding. Measures announced in 1978 to encourage the development of renewable energy resources included phased increases for R & D directed to developing technologies for obtaining energy from forest biomass. Thus, funding will be increased to $7.0 million in 1982/83 from $6.2 million in 1981/82, for the ENFOR contract program. This program is showing considerable success and it is expected that by 1990 there could be insufficient mill wastes to meet the potential for biomass energy. Consequently, R & D is being directed to harvesting techniques and technology. On the conversion side, current R & D emphasis is on the production of synthesis gas and other prepared fuels. The technology for producing methanol from synthesis gas is well established. Research is also underway on the direct liquefaction of wood, using hydrogenation processes, to produce a heavy oil. This oil could be substituted for No. 6 residual oil and chemical upgrading could convert it to diesel fuel and/or gasoline.

Most of the government's S & T related to nuclear power is conducted by Atomic Energy of Canada Limited, whose program ranges from fundamental research, essential to understanding nuclear technology, through R & D to improve the CANDU system reliability and safety, to new applications of nuclear energy. Over the past 4-5 years increased emphasis and resources have been devoted to developing the technology for the safe disposal of radioactive waste from the operation of nuclear power systems and to developing ways in which nuclear power can help solve Canada's major energy problem, a shortage of cheap oil.

As more nuclear power systems are installed, considerations of economically-available fuel may dictate the need to develop advanced fuel cycles to replace the once-through, natural uranium cycle currently used in CANDU systems. For example, thorium-based fuel cycle offers both the promise of low cost energy for centuries and the continued use of the CANDU technology, i.e., another reactor would not have to be developed.

The Canadian approach to the safe permanent disposal of radioactive material is to immobilize the material in a water-resistant matrix and dispose of it deep in a stable, hard rock formation in the Canadian Shield. The R & D program includes laboratory-scale work on immobilization of both used fuel and separated wastes. Work on used fuel immobilization is focussed on the design of high-integrity containers with an expected life of some 300 to 500 years. With this containment, it is expected that a very low risk of leakage to the biosphere of radioactive fission products during their hazardous lifetime can be achieved.

The Waste Management R & D program is now well established and significant progress is being made. To obtain the necessary geotechnical understanding for the disposal program extensive drilling is being carried out in several different rock formations. An underground research laboratory is being built in the Lac du Bonnet batholith near the agency's Whiteshell Nuclear Research Establishment at Pinawa, Manitoba.

At the "front end" of the fuel cycle, the Canada Centre for Mineral and Energy Technology in the Department of Energy, Mines and Resources is working to improve the technology for recovering uranium, thorium and other valuable products from ores, while minimizing the discharge of radioactive materials in the tailings.

In line with the probable need to increase the use of coal, the National Research Council, in cooperation with the Department of Energy, Mines and Resources, is strengthening its research effort on Atlantic coal. The Council's Atlantic Research Laboratory is in the process of defining a cooperative program that is expected to cover coal conversion processes, combustion methods and the resolution of scientific problems connected with the basic nature of coal. The research will be conducted under the guidance of a recently established Committee on Atlantic Coal.

Environmental Issues

This section deals with scientific activities related to environmental issues such as acid rain and air pollution, toxic substances, pollution control, weather and climate services and other environmental issues. Research on environmental issues is necessary to develop policies, regulations and guidelines that will ensure that the availability and productivity of our renewable resource base will be maintained for future generations. It also helps to develop, in advance, the information base required to formulate environmentally-sound industrial development plans.

Departmental and agency expenditures on environmental S & T are shown in Table 3.6. Those of the Department of the Environment ($50.0 million) far exceed the others so the following discussion concentrates on its S & T activities. The environmental S & T conducted by the Department of Energy, Mines and Resources ($4.1 million) is concerned with investigating the impact of energy development, mining and smelting activities, and the impact of the geological environment on development. The $5.4 million being spent in 1982/83 by the National Research Council in this area is directed principally to biological research on waste and pest management. The Natural Sciences and Engineering Research Council has allocated $3.8 million for research on environmental toxicology under its Strategic Grants program. With an estimated expenditure of $3.0 million, the Department of Fisheries and Oceans will, in addition to S & T concerned with acidification of freshwater lakes (acid rain), continue its ecological studies on stream rehabilitation.

Acid Rain and Air Pollution

A decade ago, higher smokestacks were still thought of as the answer to local air pollution problems. The use of such stacks resulted in dilution and dispersion, with the pollutants being transported over long distances through the atmosphere, with some concurrent chemical transformations. This process is referred to as Long-Range Transport of Airborne Pollutants (LRTAP). Acid precipitation, a mixture of sulfate and nitrate compounds with rain or snow, is a serious international consequence of this phenomenon. Thou-

Table 3.6

Federal Science Expenditures on Environmental Issues

	1980/81		1981/82		1982/83	
Department/Agency*	S&T	R&D	S&T	R&D	S&T	R&D
			(millions of dollars)			
Total	**57.7**	**29.8**	**63.9**	**34.2**	**71.9**	**38.5**
Energy, Mines and Resources	2.9	2.9	3.4	3.3	4.1	4.0
Environment (Total)	40.8	16.6	42.9	17.6	50.0	21.0
Atmospheric Environment Service	2.7	2.7	3.1	3.1	3.4	3.4
Environmental Conservation Service	27.1	7.9	29.4	8.5	34.1	9.8
Environmental Protection Service	8.8	5.4	8.2	5.3	10.0	7.1
Fisheries and Oceans	2.4	1.3	2.6	1.3	3.0	1.4
National Research Council	3.7	2.4	6.6	5.1	5.4	4.5
Natural Sciences and Engineering Research Council	3.5	3.5	3.1	3.1	3.8	3.8
Others	4.4	3.1	5.3	3.8	5.6	3.8

* Directly-related S&T expenditures by other departments and agencies in 1982/83: National Health and Welfare, $1.9 million.

sands of lakes are affected by acid rain, the result of pollution from large industrial areas and vehicles, and many of these can no longer sustain normal aquatic life. Another concern is the impact of acid rain on forest productivity and on agricultural crop production.

In response to this emerging environmental crisis the government announced in the Fall of 1980, a significant expansion of the science activities related to acid rain which were already underway in the Departments of the Environment, Fisheries and Oceans and National Health and Welfare. Four-year increases of $10.0 million for Environment, $12.4 million for Fisheries and Oceans and $3.7 million for National Health and Welfare brought the government's anticipated science expenditures on this problem to about $41 million over the four-year period. The subject is also being addressed (in the context of land degradation) in a Department of Agriculture Land Use and Evaluation Program.

The Environmental Health Directorate of the Department of National Health and Welfare will assess the risk to health posed by the long-range transport of air pollutants and will monitor the influence of abatement programs on this risk. This assessment will include both the direct (airborne pollutants) and the indirect (drinking water) effects of these pollutants. The department plans to spend $0.9 million in this area in 1982/83.

Within the Department of the Environment, the Atmospheric Environment Service's much expanded effort in the long-range transport of air pollutants and acid rain will contribute to the development of a bilateral agreement with the United States to deal with the problem. The work has three major components. Firstly, an extensive network of stations will monitor the current amounts and trends in the chemical constituents of the air and precipitation. Secondly, computer techniques will be used to model the pathways through the atmosphere of the main sulphur and nitrogen acidic compounds in the atmosphere. These models will allow the deposition of acid materials on a sensitive receptor to be quantitatively related back to the emission source regions. The third component is research on the physical and chemical processes of air pollution transport, transformation and deposition to support and improve the modelling capabilities.

The Environmental Conservation Service undertakes activities related to the development of a capability to predict impacts of airborne pollutants on aquatic and terrestrial ecosystems, and the monitoring of changes and trends of these impacts. Socio-economic studies related to the long range transport of airborne pollutants are also included. Examples of these activities are eco-district mapping according to the sensitivity to acid rain, studies of the sensitivity of land to acid precipitation in the area of Turkey Lakes in the Algoma District of Ontario, group studies to investigate the role of ground water systems in buffering acidity and providing a delayed response to acid rain fallout and studies of water chemistry and the effects of acid rain on waterfowl and fish.

The Canadian Forestry Service's program in acid rain and air pollution focuses upon Canada east of the Manitoba/Ontario boundary and smaller areas in Alberta and Manitoba. The threat of reduced forest productivity and degraded forest ecosystems is the prime concern. This could be caused by the direct action of precipitation upon vegetation tissues or indirectly through forest-soil impoverishment. The program aims to quantify the degree of injury being brought about by the different components of acid rain and to indicate abatement levels necessary to preserve environmental values.

New resources are permitting greatly expanded field and laboratory studies. Three major catchment studies have been initiated, in collaboration with other agencies, in representative forest and soil types encompassing the zones of medium to heavy acid precipitation in eastern Canada. A variety of investigations, ranging from tree foliage through the vegetation/soil complex to soil leachates, will show how deposited pollutants stress the forest system.

The Department of Fisheries and Oceans has initiated an accelerated program of research on acid rain in support of the implementation of national and bilateral controls. The resources most immediately threatened by acid rain are the freshwater fisheries located in the sensitive Pre-Cambian Shield of Eastern Canada; acidification has already eliminated salmon populations from nine rivers in Nova Scotia. The objectives of the program are to quantify the effects of acid rain on fish and define trends in acidification; to provide an understanding of the mechanisms governing susceptibility of aquatic systems to acid inputs; to predict the magnitude and the time frame of the impacts on fish under various acid inputs and to estimate the economic and social impacts of such changes. A national survey of the condition of aquatic habitats is underway, along with process studies in four calibrated watersheds. Whole lake acidification studies are also being carried out, along with an examination of the feasibility of remedial measures, such as liming, to protect fish stocks in jeopardy. Experimental surveys are planned to develop and test methods for estimating the economic and social impacts of acid rain on fisheries.

Toxic Substances

Over 50,000 chemicals are currently in commercial use in North America and this number is growing rapidly. Many of these chemicals are released into the environment in quantities and ways which contaminate our land, water, air, flora and fauna, and thus directly or indirectly endanger human health. The persistent and toxic nature of some of these chemicals, even at low levels of exposure, may have profound negative effects on human health and on the structure and functioning of ecosystems.

The Department of the Environment is developing a set of principles and policies to manage chemical contamination in Canada in a comprehensive and cohesive way and has established a Toxic Chemicals Management Centre. Through this centre, the department intends to play a significant role in preventing or limiting the negative impacts on the natural environment and also in minimizing the involuntary risks to the health of Canadians arising from the use of toxic chemicals.

The Environmental Conservation Service conducts research and monitoring activities dealing with concentrations, transportation, sedimentation and precipitation of toxic substances and their effect on the environment. Such concentrations and pathways concern inland waters, groundwaters, soils, vegetation and wildlife. The service's role in establishing rigid controls on the use of MIREX is a case in point.

MIREX is a toxic compound used as an insecticide and as a fire retardant. Following the initial discovery of MIREX in fish by a scientist from the Environmental Conservation Service, the distribution of the compound in the bottom sediments of Lake Ontario was determined. The resulting sediment distribution maps showed that Lake Ontario has been extensively contaminated and indicated specific sources of contamination. Subsequent analyses of herring gulls' eggs confirmed that Lake Ontario samples were more concentrated in MIREX than samples from the other Great Lakes. This Canadian research eventually resulted in the U.S. Environmental Protection Agency banning the use of MIREX almost completely.

Recent research activities by the Canadian Wildlife Service have also detected the most toxic form of dioxin in gull eggs in 12 locations in the Great Lakes Basin. The discovery was made possible by applying recently-developed analytical techniques to frozen gulls eggs that have been collected over a ten year period. The Department of Environment is seeking very strict controls on this lethal chemical as a result of these findings.

During 1982/1983, the Atmospheric Environment Service will continue to carry out research to gain a better understanding of the modes of entry, movement and fate of priority toxic chemicals known to be, or suspected of being, present in the atmosphere. Elucidation of the atmospheric pathways of toxic chemicals, including mechanisms for their removal from the atmosphere, will be pursued through experimental studies and the development and application of suitable conceptual and/or mathematical models. Ongoing monitoring activities will be expanded, as resources permit, to provide much-needed Canadian information on spatial distributions as well as trends in concentrations of toxic chemicals in the atmosphere.

As part of the government's expanded toxic chemical program, the Environmental Health Directorate, Department of National Health and Welfare, will address the acute and chronic effects on human health of toxic chemicals in the workplace and in the environment and the routes of exposure of the Canadian population to these chemicals. The department plans to spend $1.9 million in this area in 1982/83.

Research on the effects of toxic pollutants on fish is an important element of the Department of Fisheries and Oceans' programs. Toxic chemicals research is continuing on metals, pesticides, petroleum products and persistent industrial chemicals, with emphasis on their behaviour in aquatic systems and impact on fish populations. Research on the nature and effects of complex wastes, (municipal discharges, pulp and paper effluent, landfill leachate), is conducted to support protection activities under the Fisheries Act. Studies on test methods to determine lethal and chronic toxicity threshholds for evaluation of aquatic hazard are continuing, although at a diminished level. In response to the detection of dioxin residues in the low parts-per-trillion level in some Lake Ontario fish, the Department has undertaken a program to upgrade its capability for ultra-trace residue analysis.

Pollution Control

The Environmental Protection Service of Environment Canada is the focal point for environmental protection activities involving other departments and agencies of the federal government. The service promotes protection of the environment by first identifying pollution problems, then developing and implementing protection and control measures. Its Water Pollution Control Directorate undertakes to clean up water pollution problems and prevent further pollution through national effluent controls and improved wastewater treatment technology. Research priorities in this area include the development of anaerobic, energy-producing sewage treatment systems, the optimization of larger treatment systems, the development of new methods of treating toxic wastes and of waste treatment systems for cold climates.

The Air Pollution Control Directorate seeks to protect public health and the environment from air pollution. It promotes a consistent approach across Canada in control of air contaminants, including the development of strategies to control acidic precipitation. This program is concerned with the monitoring and collection of ambient air data on the most common contaminants. Special air monitoring surveys are also carried out to provide information on specific problem areas. Air pollution research is concerned with improving process and control technologies for industries that emit air pollutants, understanding the nature of the environmental impacts and the mechanisms of pollution transport.

The Environmental Emergency Branch undertakes scientific studies with regard to risk analysis of activities that could result in environmental emergencies, and with regard to the development of new technology for dealing with spills of oil and other hazardous materials, including the Arctic Marine Oilspill program with an estimated cost of $7 million over five years and the Baffin Island Oilspill Study amounting to about $4 million over a four-year period.

The proper management of wastes, particularly hazardous wastes, continues to be a major priority item. A Federal/Provincial/Territorial Committee meets on a recurring basis to discuss and resolve matters of mutual concern and joint jurisdiction. Work is continuing on techniques for recovering resources from waste streams. Energy recovery systems development is funded through the DRECT program managed by the Waste Management Branch of the Environmental Protection Service.

The Contaminants Control Branch evaluates chemicals—those already in use and those not yet introduced—to determine whether their use will harm human health or the environment. Specific uses of these chemicals may be restricted or banned.

Weather and Climate Services

Virtually all of Canada's resource-based economic sectors are affected by weather and climate. Continuous efforts are being made to apply climate information to maximize benefits from these activities. The Canadian Climate Centre, within the Atmospheric Environment Service, is participating in an international study to provide better regulation of Great Lakes water levels for the benefit of the lakes' community. An analysis of the nature and impacts of drought in western Canada is underway as part of an inter-agency program aimed at reducing the adverse impacts of drought. Current work on mathematical models of climate systems will contribute towards providing a sounder basis for prediction of climate as well as providing a basis for assessing the climatic sensitivity of man's activities. Climate monitoring and information services are maintained to serve the needs of a broad spectrum of users. In response to national concerns about the impacts of climate and climate change, the Canadian Climate program is being developed. Active participation of various levels of governments as well as of the private sector and the university community is being sought.

Combustion of carbonaceous fuels results in production of carbon dioxide in the atmosphere. Worldwide increases in its concentration have been documented by measurements since the mid-fifties. Climatic warming due to the so-called "greenhouse effect" is the most striking potential consequence of the increased use of fossil fuels and is one of the concerns of the Climate program. In order to assess long-term consequences we must understand both the distribution of the added CO_2 with time, and the effects of this distribution on the climate. The first problem is being investigated by measurement and modelling activities within the Air Quality and Inter-Environmental Research Branch. In addition, the Canadian Climate Centre is developing and testing numerical models of the climate system (including the interactions between the atmosphere and ocean) as a tool to enable us to understand and predict such effects more clearly.

The Atmospheric Environment Service continues to carry out research in large-scale numerical weather prediction in support of its national Weather Forecasting System. The service is also engaged in R & D to predict weather on regional and local scales using empirical and dynamic procedures and models. This latter activity and associated meteorological systems design is carried out in support of weather services provided by Regional Weather Centres. Studies are also underway to assess the potential of Telidon technology for internal and external communication and dissemination of weather information.

Other Environmental Issues

Federal wildlife responsibilities involve the Environmental Conservation Service of the Department of the Environment in issues arising out of the need to negotiate the allocation of allowable harvest of migratory birds, and from the need to protect Canada's diminishing wildlife habitat. Consequent scientific activities include research on the population dynamics, ecological and habitat requirements, native subsistence and recreational use of migratory game birds, research on preventing damage to crops by wildlife; research on non-game birds (such as the captive breeding and reintroduction to the wild of peregrine falcons, northern seabird colonies and Canadian migratory birds in Latin America); and research on polar bears, caribou herds and other wildlife in which there is a federal interest. Research is also done to provide advice on the potential impacts on Canadian wildlife resources of major energy developments and of pervasive forestry and agricultural practices.

Food

Canada has a diverse and efficient food system which continues to provide a wide variety of high-quality foods at relatively low prices. As shown in Table 3.7, Agriculture Canada has the major role in scientific activities related to food, with 1982/83 estimated expenditures of $171.7 million. It is concerned with all food commodities except fish and fish products. The Department of Fisheries and Oceans, the National Research Council and Statistics Canada support activities in the food area. The Natural Sciences and Engineering Research Council has allocated $5.2 million to research in Food/Agriculture, as a specific area within the council's Strategic Grants program. Furthermore, the Department of National Health and Welfare also undertakes health-related scientific activities in the food area. Thus, several departments are concerned with aspects of the food processing, distribution and retailing system, sometimes referred to as the "PDR Sector".

The industries engaged in the processing, storing, transportation and retailing make up the "PDR" sector of the food industry. These industries play a major role in the Canadian economy. For example, farm products comprise almost one-fifth of total rail freight and one-quarter of the tonnage moving through the St. Lawrence Seaway. Almost one-quarter of all those engaged in general wholesaling owe their jobs to the sale of food products or farm supplies. The share of the consumer's food dollar which goes for all marketing and distribution functions now amounts to 65 cents; the farmer receives 35 cents. It is apparent that

Table 3.7

Federal Science Expenditures in Food

Department/Agency	1980/81 S&T	1980/81 R&D	1981/82 S&T	1981/82 R&D	1982/83 S&T	1982/83 R&D
			(millions of dollars)			
Total	**199.9**	**164.1**	**237.4**	**190.5**	**263.2**	**209.0**
Agriculture (Total)	140.7	131.3	155.4	145.3	171.7	162.6
Agri-Food Development Program	129.0	125.3	142.0	138.6	154.5	152.7
Agri-Food Regulation and Inspection Program	4.6	4.6	5.1	5.1	8.0	8.0
Fisheries and Oceans	36.3	16.4	47.3	21.7	52.6	21.7
National Research Council	11.2	11.2	16.5	16.5	18.1	16.7
Natural Sciences and Engineering Research Council	2.7	2.7	4.1	4.1	5.2	5.2
Statistics Canada	5.0	—	8.1	—	9.2	—
Others	4.0	2.5	6.0	2.9	6.4	2.8

the overall benefit to consumers depends on the activities in a chain of connecting services that make up the food system.

Increasing emphasis is being placed on the PDR sector in departmental S & T activities. The Department of Agriculture spends $9.2 million a year on food research as such, including approximately $0.8 million on contract research on meat and plant proteins. A PDR contract program, administered by an interdepartmental board, was established in 1978; estimated expenditures for 1982/83 are $0.9 million. The Canadian Dairy Commission estimates approximately $2.5 million for contract research in 1982/83 directed to PDR concerns in the dairy industry.

Examples of research activities concerned with food processing, storage and marketing, include such items as the development of several new skim milk powders, new types of cheeses, and new dairy products such as whey spread, frozen yogurt, milk shakes, sweets and hydrolyzed milk. New processes for blanching vegetables and fruits, making wieners, canning of mushrooms and pouch packaging have been developed and are being transferred to industry. Methods for evaluating meat, adulterated milk, and browning sugar have been developed. Research is being conducted to ensure consumer safety protection, and the nutritional content of food by reducing factors that decrease nutritional value and microbiological and chemical contaminants. New projects that have been developed include low-calorie jams, apple fiber, fruits packed in pear juice, pouch-pack cherries, and saskatoon berry syrups. New methods of producing cottage cheese, sour cream, and flavored milk products were evaluated. New processes for deboning meat are being developed. The quality of asparagus processed in retortable pouches has been found superior to conventional methods. Research is continuing on meat sampling, sanitary practices, nitrosamines in processed meat, and undesirable growth inhibition by lactic organisms.

Improvement of the rapeseed crop over the last twenty years is one of the classic examples of profitable return on monies invested in agricultural research. It is now the second most valuable Canadian crop, surpassed only by wheat. It is the progress made on seed quality through plant breeding that led the Canadian rapeseed industry to adopt the name CANOLA. This crop with its vastly improved quality, achieved by developing low-erucic acid, low-glucosinolate varieties, provides Canada with an edible oilseed for both food-grade vegetable oil and protein-rich meal for feed purposes. A process has been developed to extract protein concentrate from rapeseed meal and this concentrate is currently being evaluated for use in foods. Researchers are seeking further improvements in the quality of rapeseed to fit Canada's domestic and export markets.

The export of cereal crops is an important component of the Canadian economy. Agricultural research aims at producing better grain varieties, developing and disseminating information on improved growth regimes. Genes associated with resistance to some specific pathogen are being incorporated into varieties of several cereal crops. A similar approach to improving insect resistance is also under development.

The Department of National Health and Welfare performs extensive scientific activities related to its responsibilities for food safety and quality under the Food and Drugs Act. The department's expenditures in this area are included with those shown in the Health chapter of this publication. The department: detects and evaluates health hazards in food; determines what control is appropriate over its content of additives, agricultural chemicals, contaminants, toxins and pathogenic bacteria; determines human nutrient requirements; and contributes to the maintenance of the nutritional quality of food and of the diets chosen by Canadians.

Health laboratories will continue to monitor levels in food of volatile nitrosamines that may be carcinogenic, and to work with industry on their reduction; methodology for non-volatile nitroso-compounds will be developed.

Food contamination with halogenated hydrocarbons such as PCBs, dibenzodioxins and dibenzofurans will continue to be investigated by analysis of food (including human milk) and by study of their toxicity, metabolism and distribution. As a model of possible human toxicity, a major study of PCBs in rhesus monkey mothers and infants is being undertaken.

Fungal infestation of food products, leading to the production of mycotoxins with possible teratogenic or carcinogenic properties, remains an area of active investigation that is crucial to decisions on the marketing of affected products.

Nutrition studies will include determining the types and levels of dietary fibre in the typical Canadian diet and assessing associated nutritional effects, as well as studying the adequacy of its mineral content, the nutritional value of various oils and fats, and the impact of changing sources of protein on nutrient levels in food.

Microbial hazards in food will be investigated with special attention given to canned food imported from third-world countries and to pathogens of growing significance, such as *Campylobacter* and *Yersinia*. In cooperation with other departments, activity to reduce hazards from *Salmonella*, particularly in poultry, will continue, as will participation in activities of the International Commission for the Microbiological Safety of Food.

The food science activities of the National Research Council, estimated expenditures of $18.1 million in 1982/83 include studies on the fixation of nitrogen by bacteria resident in the root cells of legume plants. The council is studying improvements in fermentation technology for the production of starches, single-cell protein, antibiotics and alcohol from materials such as grain, aspen cellulose and animal wastes. Also under study are methods for inducing individual plant cells to grow into mature plants, and freeze-preservation techniques which can contribute to maintaining world collections of valued plant genetic stocks.

The Department of Fisheries and Oceans estimates an expenditure in 1982/83 of $52.6 million on food research. Canada is now the world's largest exporter of fish, with exports valued at more than $1.3 billion in 1979. The establishment of effective quotas, and the development of regulations, indeed the very design and basis for regulation, is totally dependent on the continuous acquisition and application of reliable information. With extension of Canadian jurisdiction to the 200 mile limit, economic and operations research in support of fisheries management have also increased.

The department continues its efforts to protect fish habitats that support Canadian commercial and recreational fisheries by administering sections of the Fisheries Act relevant to fish habitats and by assessing fish stocks contaminated by PCBs, Mirex, pesticides and mercury, and by designing controls to protect fish under the Pest Control Products Act and the Environmental Contaminants Act. Major successes have been achieved in rebuilding depleted stocks. Landings are expected to continue to increase, but at a slower rate, since the limits to growth are being approached in some stocks. Catch rates, according to area, will be maintained or continue to increase, thus reducing the net cost of catching. Energy costs, however, are escalating; studies leading to improved efficiency will be emphasized. Research into factors influencing size and distribution of stocks will continue, with emphasis on the management of multi-species fisheries. Longer-term predictive ability, essential to planning, is a major objective. Research will continue into methods for increasing the cost-effectiveness of fleet operations.

Other research is being conducted in aquaculture technology, fish health and fish genetics. Further development is directed to improve genetic stocks of fish and to improve production efficiency. Technological research programs are primarily designed to improve fish quality. Investigations are continuing on the effects of handling methods on quality and yields of fish, and on problems of quality of fish products.

The department also supports a major program of salmonid enhancement on the Pacific Coast. The S & T activities within this program include studies on fish diseases and fish nutrition and engineering research to improve the efficiency of the enhancement systems. Also being investigated are several new and promising techniques for lake and stream enrichment, Japanese-type hatcheries, stock transplanting techniques and genetic manipulation techniques. Some of these techniques have been sufficiently developed to enable consideration of pilot demonstrations.

Health

As shown in Table 3.8, the Medical Research Council, and the Department of National Health and Welfare are the largest spenders on scientific activities related to health, followed by the National Research Council and Atomic Energy of Canada Ltd.

Federal scientific activities relating to health have the ultimate goal of protecting and improving the general health of Canadians. Some specific goals are:

- to add to the store of knowledge of basic human biology and behaviour;
- to determine the deleterious effects of various factors in the natural and man-made environments on mental and physical health;
- to identify links between the living habits of individuals and the state of both their mental and physical health;
- to apply knowledge of human biology and human behaviour to improving personal health care;
- to find ways to influence individual Canadians to take more responsibility for their own physical and

Table 3.8

Federal Science Expenditures in Health

Department/Agency*	1980/81		1981/82		1982/83	
	S&T	R&D**	S&T	R&D	S&T	R&D
	(millions of dollars)					
Total	**159.6**	**117.4**	**188.7**	**141.3**	**212.2**	**157.8**
Energy, Mines and Resources	1.3	1.2	1.1	1.0	1.2	1.1
Atomic Energy of Canada Ltd.	6.2	6.2	5.8	5.8	6.7	6.7
National Health and Welfare (Total)	55.1	19.6	61.9	23.1	68.8	23.3
Health and Social Services Program	14.0	6.3	15.4	6.7	14.8	5.7
Health Protection Program	38.0	11.2	41.3	12.4	50.3	15.4
Medical Research Council	82.0	79.5	100.2	96.8	112.9	109.1
National Research Council	11.0	10.3	14.5	13.8	16.5	16.5
Statistics Canada	3.4	—	4.5	—	5.1	—
Others	0.6	0.5	0.7	0.7	1.0	1.0

* Directly-related S&T expenditures by other departments and agencies in 1982/83: National Defence, $6.4 million.

** R&D refers to R&D in the Natural Sciences only.

mental health and reduce the risks they incur when they continue to indulge in potentially harmful living habits;

- to reduce the cost and improve the accessibility and effectiveness of the health care system.

Most research supported by the Medical Research Council is aimed at advancing knowledge of the functions of the human body, in both health and disease through research in the general fields of medicine and biology. Additionally, some research is directed towards evaluating the effectiveness of new treatments and interventions in various disease states through clinical trials sometimes utilizing multidisciplinary team efforts.

In support of national health goals, the Department of National Health and Welfare conducts and supports health-related research and other scientific activities, building on basic knowledge in the biological and physical sciences, the health sciences and the administrative and social sciences. About 75% of its S & T expenditures occur in its Health Protection Program, about 22% in the Health and Social Services Program and the remainder in the Medical Services program.

Within the Health and Social Services Program, the National Health Research and Development Program supports extramural scientific activities related to physical, chemical and biological hazards to health occurring in the environment, including the workplace. In addition, the program provides financial assistance to individuals across Canada for scientific investigations on social, cultural and economic factors that affect health, health care delivery systems and the enhancement of healthy behaviour by individual Canadians. Health themes that will receive special emphasis for research support in the coming years include primary and secondary illness prevention, the needs and special problems of the socially or physically disadvantaged or handicapped, and strategies for the reduction of perinatal and childhood illness and death.

Translating the results of such investigations into educational programs designed to improve individual attitudes and life habits as they affect physical and mental health is also part of the work of the Medical Services Branch, particularly in the Indian and Northern Health Program, as well as of the Health Promotion Directorate. Research on social and cultural factors that lead to anti-social or self-destructive behaviours is supported through contracts by the Solicitor General's Department and investigation of factors affecting the health of Native People is encouraged both by the Department of Indian Affairs and Northern Development and the Department of National Health and Welfare.

The Health Protection Branch maintains control over chemicals in food. These include food additives (with functions such as colouring or preserving food), pesticide residues, monomers and plasticizers from packaging, and contaminants such as fungal toxins in grain and halogenated organics in fish. Toxicity testing in experimental animals and cell systems, toxicological evaluation, laboratory analysis, and analytical method development guide regulatory control of such chemicals in food under the Food and Drugs Act, and form the basis for the extensive provision of advice to other departments and to provinces.

Food poisoning from microbial hazards in food is traced back to its origin whenever possible, e.g., to contaminated raw product, inadequate processing, post-processing contamination (such as through leaky container seams) and unhygienic food-handling and storage. Laboratory study and evaluation of these factors support prevention of foodborne microbial disease by strategies of regulation and guidelines, handler and consumer education, and technology transfer to Canadian industry and developing countries.

The impact of nutritional deficiencies on disease, although recognized, is not well understood for many nutrients, including the impacts of dietary fibre. Nutritional studies and scientific evaluation are carried out by the department, particularly in the context of the introduction of new foodstuffs (that might, for example, reduce the bioavailability of certain nutrients) and of changes in dietary habits. Work on the generation, collection and dissemination of basic nutritional data will continue, particularly in the forthcoming revision of the Dietary Standard for Canada and the development of the data base on the nutrient content of foods.

Epidemiological studies are continuing in respect of some bathing beaches of the Great Lakes, to provide data for use by the International Joint Commission and a federal/provincial committee in revising public health standards for recreational water use. In 1982/83 the department will fund the second year of an epidemiological study of the effects of environmental contaminants on the health of residents of the Saint Regis Indian Reserve, Ontario. It is suspected that the Reserve area is contaminated with such substances as mercury, MIREX, PCBs and fluorides.

The evaluation will continue of population doses from terrestrial and cosmic sources of radiation and of the potential health risks from inhaling air-borne radioactive substances and from ingesting radioactive contaminants in drinking water and food. The significance is being evaluated of radioactive fallout and routine radioactive emissions from nuclear generating stations, which also involves the comparative study of the health impacts of coal and nuclear-powered generating stations.

A major effort is being undertaken related to the safety of drugs, particularly those suspected of cancer-causing associations. For example, the alleged tumor-promoting activity of the widely-used tranquillizer, diazepam, is being investigated through animal studies and new *in vitro* techniques are being developed for detecting cancer-inducing properties of chemicals. The possible contamination of certain drugs and cosmetics with substances known to be carcinogenic in animals, such as hydrazine, nitrosamines and 1,4-dioxane, will be investigated, Parallel studies will assess the incidence of polychlorinated dioxins (which are among the most toxic chemicals known) in drugs, and the results will indicate whether regulatory action is needed.

Many of the National Research Council's health-related activities are centred in the Biomedical Engineering Research program, which also coordinates such activities in the council's other divisions. Some work is also contracted to industry in health-related areas through the council's industrial support programs, the Program of Industrial/Laboratory Projects (PILP) and the Industrial Research Assistance program (IRAP). One such PILP contract concerns the evaluation of "Blissymbol" Terminals, used by disabled persons who can neither speak nor communicate with the world around them. Under IRAP two projects are being supported - one for the development of oxygen-permeable silicone for use in contact lenses, and the other for the development of a blood flow analyzer. The PILP and IRAP programs are further described in the Industry section and also in the section which describes the council itself.

Another health-related activity of the National Research Council concerns the application of interactive computer graphics as a diagnostic tool for the cardiologist, in analyzing heart-related wave forms.

Another example concerns an aid to the diagnosis of gonorrhea, a venereal disease that has reached epidemic proportions throughout the world. A highly sensitive, reliable diagnostic technique has been developed, based on the council's research involving a study of the structures of complex molecules (called antigens) attached to the outer walls of bacteria. A particular lipopolysaccharide structure is common to all tested strains of N.*gonorrhea*. When injected into laboratory hens, this lipopolysaccharide produced a powerful antigenic response; large numbers of very specific antibodies were generated in the chickens' blood. This hen antiserum, when mixed with very small numbers of gonorrhea bacteria, causes a clumping or agglutination to occur, which can be readily detected.

The National Research Council makes a financial contribution in the health area to the Canadian Rehabilitation Council for the Disabled. It is used to support an organization called Technical Aids and Systems for the Handicapped (TASH), a non-profit company affiliated with the Rehabilitation Council. The objective of TASH is to market, service and encourage Canadian manufacture of aids to the handicapped which are unavailable through other means.

The Rehabilitation Technology Unit based at the Sunnybrook Medical Centre in Toronto is also supported by the council. The unit's role is to provide a means of developing aids which would otherwise not be developed and of making these aids available to the handicapped. The development of a new aid, from initial concept through to final product that can be purchased from a supplier, may take several years.

Usually the unit becomes involved after a prototype has been made and used successfully by a number of disabled persons. At that stage the developer may approach a commercial enterprise to seek its interest in having the new aid produced and marketed, or as an alternative, may apply to the unit for assistance in producing the new aid. The Rehabilitation Technology Unit relies on institutions and rehabilitation centres across Canada for the evaluation of its products, thus ensuring that the new aids will meet the needs of the disabled.

Atomic Energy of Canada Limited conducts scientific activities related to health, both to reduce exposure to radioactive emissions and to study the effects of radiation on cell biology and biological systems.

A recent health initiative being supported by the federal government is the establishment of the Centre for Occupational Health and Safety. The centre is an independent, self-governing body, reporting to Parliament through the Minister of Labour. Its mandate is to provide a common focus and impetus for activity and progress in all areas of occupational health and safety. The centre's affairs and activities are determined by a council, comprising representatives of federal and provincial governments as well as the principle labour and management organizations in Canada.

Work planned for 1982/83 includes the development of data bases to provide information concerning occupational safety and health, the investigation of case histories of workers suffering from specific occupational diseases, and research into the special occupational health and safety problems of native peoples.

The Defence and Civil Institute of Environmental Medicine in Toronto is operated by the Department of National Defence as a defence research centre concerned primarily with human performance in adverse environments. It includes the provision of research facilities, medical training and clinical services in support of the human performance interests of other government departments and agencies and of industry. One of its unique facilities is a crash simulator system. The system provides impact simulations which are typical of vehicular crashes and includes a test specimen sled, a 120' long precision track, associated computer monitoring control systems and instrumented dummies for the detection of impact stresses. This facility has been used by the Ministry of Transport in the evaluation of car safety belts and has been used by the institute in evaluating helicopter pilot restraint systems.

The Institute also has Canada's most complete and extensive diving research facility. It is used as a national facility to train and experiment with personnel involved in diving and especially in deep-diving. Dives in this facility usually last approximately two weeks, including the time needed for compression and decompression of the subjects.

Another facility is called a Precision Angular Mover. It is used to provoke and study motion sickness in order to reveal the stimulii causing it, and to test anti-motion sickness drugs. This unique machine was used for motion-sickness tests of the crew of NASA's Spacelab and it will be used for similar tests on the next Spacelab crew, in which it is hoped a Canadian astronaut will participate.

Although it does not report activities in health science, the Social Sciences and Humanities Research Council (SSHRC) does support theoretical, policy-oriented research in some health-related fields—psychology, sociology, social work and education. In other areas supported by the council, health-related studies include such things as the history, economics and politics of health-care delivery systems and preventive services, public health policy and administration, and changing population fertility patterns.

In the directly health-related fields, council-funded researchers contribute for example to an understanding of what induces anti-social behaviour, and economic and social forces such as ageing that may affect the quality of life and individual adjustment to changed conditions. A medical/social/psychological study of newborn infant behaviour is being funded by the council at Dalhousie University. The study has prompted the establishment in Halifax of an active laboratory for inter-disciplinary research in conjunction with a local obstetric hospital. In the public health policy field, the council has funded an analysis of health-care financing in Newfoundland, and an economic evaluation and comparison of the dental-care programs for children in Newfoundland and Saskatchewan. With a grant from the council's Strategic Grants program, sociologists at the University of Manitoba, in collaboration with the university's department of social and preventive medicine, are assessing community support networks for the elderly. Psychologists and educationists in other Canadian universities are exploring the theoretical aspects of individual and community attitudes to aging and the well-being of the elderly themselves.

Natural Resources

This section is concerned mainly with the S & T activities related to the evaluation, development, management and utilization of Canada's land, water, forestry and mineral resources.

Water

Canada possesses approximately one-quarter of the world's volume of freshwater; freshwater covers nearly 8% of the country's surface. This resource has a profound effect on the economic, social and environmental welfare of the nation. As shown in Table 3.9 essentially all of the federal scientific activities concerned with water as a resource are reported by the Department of the Environment. The Department of Agriculture has underway the development of agricultural practices to conserve water. In addition, some of the S & T supported by the Canadian International Development Agency is related to the water resources application area.

Within the Department of the Environment it is the Environmental Conservation Service which is concerned with the wise and careful use of Canada's water, including its long-term availability and quality, and also its allocation among competing uses based on sound economic, social and ecological considerations.

The service, in conjunction with various other agencies and levels of government, conducts research, collects data, monitors, and plans activities relating to Canadian waters and also undertakes a variety of activities under specific international agreements. These scientific activities are conducted under a number of programs, which cover a wide range of responsibilities with varying degrees of involvement such as: Flood Damage Reduction activities, Water Quality Management, River Basin Planning and River Basin Plan Implementation, and Water Management Research and Water Management Data. The specific activities cover a wide scope, from those dealing with ice hydrology to those related to the impact of nutrients.

The service's continuing investigations of the role of glaciers as an influence on stream flow in mountainous regions helped avert a possible tragedy in a remote area of northwestern British Columbia. It was noted during a survey of the area in late July that Flood Lake—a body of water impounded behind the Flood Glacier—was nearly full and ready to release its waters downstream. Discharge from such a glacier-impounded lake, when it occurs, can be sudden and catastrophic. All or most of the lake water will be released within a very short period. The service, through its regional offices, notified provincial authorities. Discharge occurred in mid-August, raising levels in

Table 3.9

Federal Science Expenditures for Water Resources

Department / Agency*	1980/81 S&T	1980/81 R&D	1981/82 S&T	1981/82 R&D	1982/83 S&T	1982/83 R&D
	(millions of dollars)					
Total	**17.4**	**4.6**	**19.1**	**5.2**	**22.2**	**5.9**
Environment (Total)	16.2	4.6	17.6	4.9	20.6	5.7
Environmental Conservation Service	16.2	4.6	17.6	4.9	20.5	5.7
Others	1.2	—	1.5	0.3	1.6	0.2

* Directly-related S&T expenditures by other departments and agencies in 1982/83: Agriculture, $1.5 million.

the flood plain of the Stikine River 40 km downstream by about 2 m. A party of campers had been persuaded to move from the area affected by the flood to a higher area a short time before. Research by the Environmental Conservation Service on glacier outburst floods is directed toward the development of methods to predict the magnitude, timing and duration of these floods.

Studies aimed at improving the capability to predict floods will continue. Experience with spring flooding in far-northern rivers and with joint federal-provincial flood damage reduction agreements has shown that the effects of flooding due to ice-jamming constitute a major problem but are little understood. More emphasis will be placed on research studies of these phenomena. A LANDSAT Application Package has been developed which permits mapping and monitoring of the concentration and distribution of suspended sediments. This approach is more economical than older surface-sampling techniques. The new package was developed to support feasibility studies for the Fundy Tidal Power project. A user manual detailing the package is soon to be published.

The Department of Agriculture has underway the development of agricultural practices to conserve water and to adapt them to semi-arid conditions. In addition, research is also performed on irrigation systems, land drainage, salinity control, ground-water behaviour, water quality, erosion and modelling of water use of crops. Agriculture Canada spends $1.5 million annually on water research.

The Land

The wise use and sound management of Canada's land resources are essential to the attainment of many of the nation's goals. Much of what the Federal Government does, influences the use of the land resource. Land is the basis of national sovereignty, a primary factor in production of food and fibre and its use is a determinant of the quality of life for present and future generations. Sound land use is therefore fundamental to achieving Canada's political, social and economic goals.

Most Canadians live on and use less than one-tenth of the nation's land resource; but that land is the best land for nearly all purposes. Conflicts between demands for land for urban and industrial purposes, agriculture, forestry, mining, transportation and recreation are serious locally, and in sum can have profound national, social and economic consequences. As a result, the Department of the Environment through its Environmental Conservation Service has an on-going program to document the nature and extent of land resources, including levels of management and allocation among competing uses.

Programs are also underway to analyse prime agricultural land around cities, the increased need for industrial and residential land at its high cost, the impact of energy demands on other land uses, questions of access for mineral exploration and development, the settlement of native claims and the preservation of unique habitats and implementation of land use policy within the Federal Government, the analysis of land use problems and issues, advice on management, acquisition and disposal of federal lands, planning advice to the provinces, the mapping of changes in the use of Canada's land and the relationship of this to an on-going program to map land use capability through the Canada Land Inventory and ecological land classification. Examples of present research activity include a nationwide study of different stresses on the land resource ranging from industrial activity to waste disposal, to soil-depleting agricultural practices. The Canada Land Use Monitoring Program is documenting the changes in land use in urban centred regions and is gathering and analyzing information on several prime lands areas with respect to land use change. A major study on the loss of agricultural land, its causes and national consequences is nearing completion, documenting the increasing dependence of the nation on the best food-producing lands.

The Department of Agriculture devotes $6 million annually to research on soil management, soil conservation, soil survey, land evaluation, land use and to basic soil research. A further $1.5 million is devoted to research on environmental quality. A significant portion of the $40 million spent on crop and protection research is also related to land use.

Forestry Resources

In Canada, with one of the major forests of the world, forest products manufacture and forestry itself account for the direct and indirect employment of about 10% of the labour force, constitute the largest component of export earnings and are second only to food in total value of shipments. In addition, the forests support an abundant wild life, influence our climate, provide major recreational and tourist attractions and are a potential source of considerable quantities of energy. A major consideration in planning forestry R & D is its long term nature. Trees require fifty or more years to mature, so that payoff from R & D does not come quickly. Thus the whole history of forestry R & D in Canada has existed for little more than one growth period.

In recent years, the annual timber cut has begun to approach, and in certain areas, exceed the annual growth and it is estimated that currently, the area of inadequate regrowth is increasing at about 200,000 hectares (2000 km_2) annually. In the coming years, it is imperative that not satisfactorily restocked forest lands be returned to productivity and that the annual production capacity of the remaining forest lands be judiciously increased to meet the expected increase in demand for forest products.

As shown in Table 3.10, almost all the government's expenditures in forestry and forest products S & T are made by the Canadian Forestry Service, Department of the Environment. Expenditures for 1982/83 are expected to be some $62.4 million. The intramural expenditures specifically exclude S & T related to forest products. S & T support for forest products is performed extramurally under (i) a contract with Forintek Canada Corp., for the conduct of certain R & D studies, and (ii) a contribution toward Forintek's cost of maintaining two services from coast-to-coast: a technical advisory service for wood products manufacturers and the general public, and a codes and standards group to assist other government departments and industry associations. The total amount paid to Forintek in 1982/83 is expected to be $4.6 million. In addition, the Canadian Forestry Service funds 50/50 with industry the research program of FERIC. This program is aimed at improving the efficiency of wood harvesting operations and at minimizing the cost of wood used in the manufacture of forest products.

The S & T activities of the Canadian Forestry Service are devoted to promoting more intensive management of the forests and in the future will stress the enhancement of their productivity both by improving growth and minimizing losses. The annual cut of the Canadian forests amounts to about 800,000 hectares (8,000 km_2) or about 0.5 percent of the total available for industrial wood production. Each year about 100 million cubic metres of wood are destroyed or damaged by fire, insects and disease. This is equivalent to about one-third of the allowable annual cut of softwoods. In fact, the extent of the present spruce budworm infestation is about 50 million hectares (500,000 km_2) of forest. Various ways of overcoming these problems include increasing the rate of reforestation, tending young stands and breeding better trees that grow faster and are resistant to pests. Environmentally benign methods of controlling pests by replacing chemical spraying with biological methods are being developed using bacteria, hormones and viruses specific to budworm or other organisms. Improved methods of firefighting, involving both equipment and management techniques, are also being developed.

Remote sensing techniques are potentially useful in forestry studies, and should be particularly useful for locating and following the progress of fires. Much of the required development of equipment for retrieval, storage and processing of the output of satellite-borne sensors is done under contract by industry. An inventory and monitoring system, optimized for use by a forestry company will be developed and documented by 1982. By 1983, procedures will be developed to update provincial forestry information with respect to clearcuts, roads, burns and major forest damage.

Canadian industry has also refined its capability to apply airborne remote sensing techniques (developed by the Canada Centre for Remote Sensing of the Department of Energy, Mines and Resources) to the detection of frost pockets in tree nurseries — an important aspect of modern silviculture. Canadian Forestry Service's scientists are continuing to use remote sensing data to study spruce budworm defoliation in New Brunswick and Cape Breton Island, species identification and other aspects of damage appraisal.

Table 3.10

Federal Science Expenditures for Forestry Resources

Department/Agency	1980/81 S&T	1980/81 R&D	1981/82 S&T	1981/82 R&D	1982/83 S&T	1982/83 R&D
	(millions of dollars)					
Total	**46.5**	**41.8**	**53.1**	**48.2**	**63.5**	**57.8**
Environment (Total)	46.2	41.7	52.4	47.9	62.6	57.4
Canadian Forestry Service	45.9	41.6	52.1	47.8	62.4	57.3
Others	0.3	0.1	0.7	0.3	0.9	0.4

Within the industry, the increasing need to use trees of smaller diameter or poorer quality has necessitated the development of new equipment to maintain product quality and restrain production costs. For example, production of traditional long-length upper-grade hardwood lumber for the manufacture of furniture is decreasing in both Canada and the USA due to the decrease in average tree size and quality. Since most furniture components are less than four feet in length, greater attention is being given to the production of short lumber in sawmills using equipment designed to accomodate logs 8 feet and less in length. The need for new equipment has led to the development of innovative machinery such as the wood slicer, to minimize sawdust loss and increase lumber yield per net log volume. The decrease in tree quality and resultant increase in plywood costs, is causing a major shift in demand from plywood to waferboard. At the same time, the rising cost of petroleum-based adhesives for waferboard has led to the development and gradual acceptance of much cheaper adhesives based on spent pulping liquors. In addition, wood waste and poorer quality forest stands not presently utilized are potentially a major renewable source of energy through combustion or conversion to other fuels. As fibre demand increases steadily and the delivered cost of fibre from wild forests increases rapidly, attention must be focused on the development of rapidly-growing genetically superior trees for planted forests and processing techniques to maximize their annual yield.

Mineral Resources

Exploitation of Canada's mineral resources is an important factor in our economic prosperity; in 1978 mineral processing and products contributed about $26 billion or 10% of Gross National Product; 42.5% was export business.

Table 3.11 shows that essentially all the government's reported science expenditures for mineral resources are under the aegis of the Department of Energy, Mines and Resources, in support of its responsibilities for national mineral policy and coordination. These responsibilities include economic analysis and assessment, transportation and environmental considerations, technology development, the provision of a wide range of geoscience information, the development of mineral exploration techniques and methodologies, and policy recommendations. Within the department, the Minerals and Earth Sciences program collects and disseminates a wide range of geoscience information about the Canadian landmass and continental shelf.

The major federal R & D organization concerned with mineral technology is the Canada Centre for Mineral and Energy Technology (CANMET), which performs, funds and coordinates research to ensure that adequate technical capability is available for the supply, processing and use of minerals. This includes the provision, through formal and informal techniques, of specialized information and advice needed for policy-making and for improved industrial practice.

CANMET cooperates with other agencies to evaluate the technological and economic recoverability of resources such as complex base-metal sulphide ores, platinum-group minerals, and precious metals, but the main thrust of its work is to develop improved technology for mining, processing and utilization. In addition to addressing strictly questions of technical and economic feasibility, the research aims to maintain high standards of energy efficiency, environmental acceptability and health and safety.

The emphasis in CANMET's mining research has shifted from pit slope design to underground mining. Expertise in rock mechanics is being applied to improve ground stability, safety and productivity, especially in difficult conditions. Health and safety are also major

Table 3.11

Federal Science Expenditures for Mineral Resources

Department/Agency	1980/81		1981/82		1982/83	
	S&T	R&D	S&T	R&D	S&T	R&D
			(millions of dollars)			
Total	**21.5**	**14.3**	**29.6**	**21.7**	**32.1**	**25.5**
Energy, Mines and Resources (Total)	21.4	14.2	28.9	21.2	31.4	24.9
Mineral and Earth Science Services Program	21.4	14.2	28.9	21.2	31.4	24.9
Others	0.1	0.1	0.7	0.7	0.7	0.6

concerns, the objective being to develop individual and integrated systems to measure and predict hazards from noise, vibration, dust, radiation and toxic diesel emissions. Personal dust and radiation-measuring instruments and devices to reduce diesel exhaust emissions by 70% have been developed.

In the long-term national interest, CANMET has traditionally put much of its effort into technology for low-grade, or complex mineral resources, especially those that are of particular regional interest. An example is the massive sulphide ore deposits of New Brunswick, in respect of which CANMET has made progress with several processing techniques to increase recovery of metals and by-products and to reduce harmful effluents. Mineral wastes are also being examined as sources of a variety of materials ranging from alumina to precious metals.

Two major projects are directed at reducing environmental pollution in mineral operations. For several years, CANMET has been exploring techniques for containment and disposal of uranium mine and mill tailings and the removal of radioactive contaminants from related process and effluent streams. Federal-provincial discussions have been held to coordinate the long-term management of tailings. A major effort was recently started on ways to reduce sulphur dioxide emissions from metallurgical operations.

At the utilization end of the mineral cycle, materials integrity and durability are serious economic concerns, particularly in harsh Canadian climates. Metal corrosion, for example, is estimated to cost Canadians seven billion dollars a year. CANMET is working to reduce corrosion and wear and to improve welding technology in a variety of applications.

The importance of metals in transportation systems is recognized through CANMET's metallurgical research. Scientists have investigated methods for producing a premium rail suited to Canadian conditions. For automobiles, useful comparative data have been acquired through experiments with lightweight and corrosion-resistant steels. Research is also underway on improved alloys for ships in Arctic service.

Cooperation and collaboration with industry are essential to CANMET's mission. Through contracts, joint projects, and a sophisticated information transfer system, the Centre works to ensure that industrial needs are met and that technical capability is available for prudent and efficient resource development in Canada.

Explosives specialists in the department's Explosives Branch provide the technical expertise needed in the implementation of the Canada Explosives Act. Over the years they have tested many thousands of explosives and incendiary devices for integrity and safety, and developed improved testing and evaluation techniques.

The objective of the Geological Survey of Canada is to provide a comprehensive knowledge base respecting the bedrock, surficial geology and the mineral and energy resources of Canada. To meet this basic objective, the wide variety of projects currently being undertaken individually cover specific areas of Canada or specific branches of geoscience. Investigation of the geology and mineral resources of the Selwyn Basin and adjacent areas of the Yukon and NWT continue to attract the interest of mineral exploration companies. Previous studies of the younger volcanic belts of the Cordillera provide the base for advice concerning geothermal energy sources in the area north of Vancouver. Field and laboratory investigations of the sedimentary basins of western, Arctic and eastern Canada and of the offshore areas enable the provision of biostratigraphic information to petroleum exploration companies and provide basic data needed to supply independent evaluations of Canada's petroleum, natural gas and coal resources. Correlation studies based on samples obtained from drilling and dredging in the Atlantic offshore are being extended to areas of probable petroleum exploration. In anticipation of future exploration in deeper waters, new techniques are being developed to study very thick sedimentary sections.

Deep crustal and shallow geophysical experiments similar to the successful Lorex and FRAM I projects will be continued in the Atlantic and Arctic offshore. These experiments will aid in understanding the evolution of this continent. Studies in the Precambrian Shield will be concentrated in the western Mackenzie valley, where important new theories on the evolution of the shield are being tested, and in the central Keewatin area, where the relation of mineral deposits, in particular uranium, to the geology is of great importance. Investigations of occurrences of metallic minerals are being combined with those of regional geology to provide insight into the origin of mineral deposits. This knowledge is used to prepare mineral assessments of strategic commodities, and of parks and other proposed land reserves in the Northern Territories. Terrain inventory mapping and process studies are planned in order to provide data on probable areas of future development. In the past, aspects of this work have been used to prepare environmental assessment reports of pipeline and other transportation routes.

Prediction of the impacts of man-made conditions on the environment (such as acid-rain and waste disposal) requires improved understanding of surficial and near surface processes in recent geological times.

The Geological Survey also undertakes geophysical exploration and geochemical surveys on a regional scale, and is deeply involved in developing new techniques and instruments. Recent improvements to aeromagnetic surveying equipment are in the process of being transferred to the Canadian geophysical industry. Promising developments for future technology transfer are arising in borehole logging techniques, airborne detection of natural radioactivity and radar sounding of bedrock fractures. The continued strength of Canada's geophysical and geochemical exploration industry is also aided through the Geological Survey's support of pertinent unsolicited proposals, and the unbiased field testing of new equipment.

Resource analysis and exploration are iterative processes; each iteration reveals the need for more information or for refinement and changes in methodology. The information provided is directly used by industry as an aid to the discovery and development of mineral and energy resources. The mineral industry has repeatedly declared that the high quality of information provided by the department continues to make Canada attractive for resource exploration.

The Canada Centre for Remote Sensing has undertaken a number of operational projects jointly with the exploration industry to apply remote sensing technology. These have resulted in significant ore-body discoveries in British Columbia, Alberta and Nova Scotia. Methods developed recently at the centre use vegetation textures to highlight geological structures and have been widely used. The technique promises to be one having special significance for geological exploration in heavily forested countries, where surveying is more difficult than in open terrain areas. This application package is being transferred to service industry for continued operational use in the mining and exploration industry.

The Earth Physics Branch conducts interdisciplinary field surveys and research to establish and improve understanding of the basic geophysical framework of Canada, thus contributing to the knowledge base necessary for the effective utilization of the Canadian land mass and its resources. The 1979 LOREX geoscience study of the Lomonosov Ridge near the North Pole has contributed significantly to our knowledge of the evolution of the Arctic. Seismic studies are used both to measure and to attempt to predict earthquakes. The behaviour of seismic waves is used as a tool in determining deep earth structure.

Oceans

Canada, despite her massive land mass, is physically a maritime nation. The waters of the Atlantic, Pacific and the ice-laden Arctic Oceans bathe our shores, which in total length exceed those of any other country. Resource riches, renewable and non-renewable, abound.

However, we are a maritime nation in terms of consciousness as well. Our forefathers arrived here after long and often difficult sea voyages; our early settlements hugged the coast; industries relied on marine resources for their raw materials or on ships as the means of taking their goods to markets.

The pace, moreover, is quickening. Canada is presently in the midst of a major expansion of its reliance on ocean resources and marine-based activities. In 1977, for example, Canada extended its fisheries jurisdiction to 200 miles, thus claiming full management control and responsibility for fish stocks within those limits. Offshore oil and gas exploration has been progressing for over a decade, with exciting results and intense technological challenges in such hostile environments as the Beaufort Sea, the Arctic Islands, the Grand Banks and the Labrador Sea. Soon, these exploration activities will be giving way to development, with resulting requirements for new transportation systems to bring oil and gas to markets, often through ice-infested waters.

All of these activities depend on a scientific knowledge of the oceans and of the inter-relationships between the marine environment and human activities. Moreover, the development of new technologies and instruments is required to cope with the demands imposed by marine conditions, and to measure and investigate complex oceanic phenomena. The federal government carries out many S & T programs related to these ocean activities, as indicated in Table 3.12. The largest expenditures are those of the Department of Fisheries and Oceans, the Department of the Environment, of Energy, Mines and Resources and of the National

Table 3.12

Federal Science Expenditures in Oceans

Department/Agency*	1980/81 S&T	1980/81 R&D	1981/82 S&T	1981/82 R&D	1982/83 S&T	1982/83 R&D
	(millions of dollars)					
Total	**57.0**	**27.4**	**60.6**	**29.5**	**73.4**	**31.6**
Energy, Mines and Resources	7.6	5.4	7.8	5.2	9.2	6.6
Environment (Total)	10.0	—	10.2	—	12.5	—
Atmospheric Environment Service	10.0	—	10.2	—	12.5	—
Fisheries and Oceans	31.2	15.5	31.8	15.8	35.5	15.9
National Research Council	4.7	3.2	5.9	4.5	6.1	4.6
Natural Sciences and Engineering Research Council	2.4	2.4	2.7	2.7	3.3	3.3
Regional Economic Expansion	—	—	0.5	—	5.1	—
Others	1.1	0.9	1.7	1.3	1.7	1.2

* Directly-related S&T expenditures by other departments and agencies in 1982/83: National Defence, $5.3 million.

Research Council. It should be remembered also, that oceans S & T activities overlap those in with the other application areas (e.g., food, energy, transportation, environment) described elsewhere in this publication.

The largest portion of the federal oceans S & T effort is carried out under the Ocean Science and Surveys activity of the department of Fisheries and Oceans. (Most of the science activities of that department's Fisheries Management and Research activity are discussed in the "Food" chapter of the Major Applications section.) Major components of Ocean Science and Surveys (OSS) are the survey activities of the Canadian Hydrographic Service and the oceanographic research programs of several institutes (including the Bedford Institute of Oceanography in Dartmouth, Nova Scotia and the Institute of Ocean Sciences in Patricia Bay, British Columbia). The following paragraphs outline some major issues addressed by Ocean Science and Surveys activities:

Ocean climate

Ocean properties exhibit trends of variability which we think of as "climate". While ocean climate is a major determinant of global atmospheric conditions, it also plays an important role in fish species composition, migration, availability and abundance. Consequently, changes in ocean properties over time, apart from impacting on the weather, have a pronounced effect on fisheries, on the design and behaviour of facilities for marine transportation and on offshore oil and gas production. The monitoring of ocean characteristics, conduct of theoretical and experimental studies directed at ocean climate prediction and studies on the impact of ocean climate changes on marine fisheries are key elements of an ocean climate program for the Department of Fisheries and Oceans.

Sea ice research

The presence and movement of ice is a continuing obstacle to transportation and resource-related activities in the Arctic and also on the east coast. The Department of Fisheries and Oceans, in cooperation with the Departments of the Environment and of Energy, Mines and Resources, is presently developing a major research program on the properties of sea ice and on its behaviours in response to oceanic influences like tides and currents. This work, much of which will be contracted-out, will emphasize the gaining of information (such as sea ice and iceberg forecasts) needed to permit year-round operation of tankers and liquified natural gas carriers to and from the Arctic. The important role of the Department of the Environment in the development and application of space technologies relating to sea ice and sea state information is referred to in the section on Space.

Remote sensing

The development of remote sensing techniques for the monitoring of ocean properties is also an increasingly important component supporting the Department of Fisheries and Oceans' programs. One of the major projects in this context is R & D on the use of high frequency radar to monitor waves, ice, surface winds, and oil slicks; this particular task is being carried out in cooperation with the Departments of Energy, Mines and Resources, National Defence, the Department of Communications, (Communications Research Centre) and Memorial University's Centre for Cold Ocean Resources Engineering. Another continuing remote sensing effort, which has been approved as part of Canada's space program, is the investigation of the use of satellite imagery to detect chlorophyll concentrations in water bodies. Perfection of this technique would provide the fishing industry with a valuable tool for spotting areas of possible high productivity.

Arctic hydrography

Crucial to the transportation of Arctic oil and gas to southern markets is adequate navigation information to permit safe vessel operation. Accordingly, a major Arctic survey and charting effort has been identified as an urgent national priority to be addressed by the Canadian Hydrographic Service. As part of this effort, the oceanographic research vessel, the C.S.S.*Hudson*, carried out in 1981 an intensive survey of the Beaufort Sea aimed at locating pingos and other hazards to navigation along the routes being considered for future tanker operations.

Ocean information services

The increasing pace of marine activity is resulting in a growing need by government and industry for information on various oceanic and marine atmospheric properties (e.g., wave height forecasts, iceberg movement predictions, sea surface temperature charts). The results of a major interdepartmental survey of industry and government requirements in this regard have been published. Implementation of the survey findings are being undertaken as resources permit.

Ocean industry development

The Ocean Science and Services program has included among its priorities the support of ocean industry, through the provision of information services and the enhancement of technology transfer from departmental institutes to industry. In this context, the department continues to be actively involved in technology development, and (through contracting-out, Unsolicited Proposals and the National Research Council's Program for Industrial/Laboratory Projects, PILP) in the enhancement of industrial capabilities to develop, adopt and market these technologies.

One of the major challenges facing the Ocean Science and Services program is the routine collection of physical and chemical oceanographic data needed to acquire a better understanding of large-scale seasonal and annual changes in our ocean waters. On the east coast in particular the data, along with increased expertise in remote sensing and data processing, are needed to keep up with demands for information and advice, for rapidly-expanding offshore oil and gas activities for fish stock and recruitment assessments and for the solution of various other problems related to fisheries, ocean sciences and defense. Improvement is also needed in the understanding of local surface currents to facilitate the prediction of iceberg movement along the continental shelf. Because of horizontal variability in surface currents, measurements obtained at the drilling platform are sometimes inadequate for decisions on whether an approaching iceberg should be towed away or a drill rig should be moved off site.

Marine pollution is another area of major concern for the Oceans Science and Surveys program. Problems receiving particular emphasis are organochlorine uptake in marine invertebrates, the assessment of environmental hazards of PCB replacements, and the monitoring of effluents from industrial and public utility sites such as the Point Lepreau nuclear power generating station, pulp mills and mines.

Several other departments are also involved in oceans related S & T activities. The National Research Council has begun construction of the $56 million Arctic Vessel and Marine Reseach Institute on the campus of Memorial University in St. John's, Newfoundland. The Institute, will evolve from the present Marine Dynamics and Ship Laboratory in Ottawa, and is expected to be completed by the end of 1984. The Institute will possess a world-class research capability in vessel and marine structure design, and will include among its facilities a state-of-the-art, ice-covered model towing tank.

The Atmospheric Environment Service of the Department of the Environment is undertaking research on Canada's marine climate in order to better understand the processes and exchanges of energy between the ocean surface and the atmosphere, for application to long-term numerical prediction. Applied research is also being carried out on the statistical probability of reaching extreme values in such marine parameters, as wind speed and wave height, so that information for the strategic planning of offshore drilling structures and marine transportation routes is available prior to major developments expected in the 80's, especially off the Atlantic coast. This need has led to close coordination in the assembly of ocean data bases with other federal departments, such as Energy, Mines and Resources and Fisheries and Oceans, as well as with the petroleum industry.

Research is also carried out by the Department of the Environment on the use of data from satellite-borne sensors in the determination of sea surface temperature, ocean waves and currents, and surface winds. The sensors include scatterometers, radar altimaters, microwave radiometers and synthetic aperature radars. The questions investigated include the determination of the "signatures" of the various meteorological and oceanographic parameters in terms of the readings obtained by these sensors and others in the visible and infra red portions of the radio spectrum. Remote sensing techniques promise to provide, for the first time, global measurements of characteristics of the world's oceans.

The Environmental Protection Service of the Department of the Environment also undertakes oceans-related R & D activities. Included here is the development of technologies for detecting, containing and removing spills of oil and other hazardous substances under the Arctic Marine Oilspills Program, and a $5 million Baffin Island Oilspill Study whose costs are shared on a 50/50 basis with industry.

Several activities of the Department of Energy, Mines and Resources have an oceans S & T component. Increased exploration in Canada's offshore areas, mainly for hydrocarbon resources, has increased the demand for geological information on these areas. The Geological Survey of Canada provides data on bedrock strata, the ocean floor and the processes operating on the floor and in the coastal zone that are needed for orderly development. The need for informed environmental assessment of proposed offshore dredging and mining and the dumping of waste material has placed a heavy burden on marine geologists. Data gathering in these hostile environments requires the use of ships and equipment designed for these specific purposes. One such system, the Huntec "Deep Tow" System that maps the seabed and the underlying strata, was developed jointly by industry and several federal agencies, led by the Geological Survey. Development work is being undertaken under the auspices of the National Research Council's PILP program to expand the capabilities of the Huntec system. Detailed examination of sea bottom conditions in the Beaufort Sea and the Hibernia area east of Newfoundland will provide the information required for formulation of federal regulations and the planning of engineering development. The amount of data collected continues to expand rapidly. Data handling systems, such as those under development at the Atlantic Geoscience Centre at the Bedford Institute of Oceanography will provide ready access to the data for all users.

The department's Resource Management Branch exercises regulatory control over offshore hydrocarbon exploration and production. The branch is responsible for a 3-year study currently underway to assist in assessing potential environmental impacts of oil and gas developments off the coast of Labrador. This project, Offshore Labrador Biological Studies (OLABS), is funded by the oil industry and is jointly managed by the federal government (the departments of Energy, Mines and Resources and the Environment), the Province of Newfoundland, the Labrador Resources Advisory Council, and the offshore exploration industry.

The department's Canada Centre for Remote Sensing carries on R & D with the objective of developing and demonstrating systems, methods and instruments to acquire, disseminate and analyse remote sensing data obtained from aircraft and satellites. Some of this work, in collaboration primarily with the departments of the Environment and Fisheries and Oceans, is devoted to the observation of oceanic properties (including the distribution, movement and condition of Arctic ice) and marine pollution. Included in the government's 5-year Space Plan as a major thrust with marine implications by the centre, is the development of satellite and airborne synthetic aperture radar technology and systems. The Department of the Environment has the lead role in defining mission requirements for a radar satellite which may be implemented in the late 1980s, primarily for observation of arctic ice.

The Department of Indian Affairs and Northern Development has regulatory control for all non-shipping activities north of 60°N. The department's Northern Environmental Protection Branch together with the Departments of the Environment and of Fisheries and Oceans has undertaken a major research effort, the Eastern Arctic Marine Environmental Studies (EAMES) program, aimed at ensuring that offshore oil developments proceed with minimum environmental risk. The EAMES program, which began in 1977, was jointly managed by a government-industry-native committee chaired by the department, with the majority of the funding being supplied by industry. Research is concentrated on the physical environment (e.g., ice movements and forecasting, wave climate, meteorological conditions), biological studies (e.g., wildlife abundance, distribution and behaviour) and oilspills (e.g., impact on the environment, counter measures development). EAMES information from the Davis Strait area was incorporated in an environmental Impact statement submitted to the Federal Environmental Assessment Review Office in support of exploratory drilling which began in 1979. Similarly, reports on EAMES studies in Northern Baffin Bay are expected to be submitted by Petro Canada in 1982 as part of Petro Canada's impact statement required for permission to drill in that area.

The Department has also initiated marine programs associated with Canada's two most northerly mining ventures. These are Nanisivik Mine on Strathcona Sound, Baffin Island, and Arvik Mine on Little Cornwallis Island. Although the tailings from these operations are not discharged directly into the ocean, their coastal locations present concerns for marine contamination from mine effluents. Therefore a monitoring program, developed by DIAND in cooperation with the Department of Fisheries and Oceans, was initiated in 1978 at Nanisivik. The objective of the program was to establish a baseline for heavy metals in marine indicator organisms, and, over the life of the mine, determine the significance of any contamination in Strathcona Sound. An assessment of preliminary results will be available for 1981 in a technical report. A similar program was initiated in 1980 at the Arvik site.

Transport Canada carries out various oceans-related R & D activities although the primary purpose of this work is support of marine transportation. The department's Canadian Marine Transportation Administration carries out marine R & D related to safety, pollution control, telecommunications, arctic and offshore resource development, vessel traffic management and navigation aids. Transport Canada's Research and Development Directorate also undertakes marine transportation S & T. Its Transportation Development Centre is involved in a wide range of research activities aimed at developing expertise in navigating efficiently, effectively and safely in ice-covered waters; and its Research Planning and Coordination Branch carries out R & D on energy efficiency in marine transportation and on transportation of commodities such as oil and liquefied natural gas in ice-infested waters.

A major emphasis in Transport Canada's R & D is in the development of vessels capable of navigating in ice-covered waters, even in the high Arctic, on a year-round basis. Design considerations are a major component of this work, and there is a resulting concentration on the measurement of impact, excitation and vibration forces generated and experienced by vessels navigating in the ice. The results of these studies will be used to assess the adequacy of existing vessel standards and regulations pertaining to navigation in ice-infested waters in the Arctic and elsewhere.

In this context, Cabinet authorized, in June, 1981, the expenditure of an additional $14 million over 3 years for R & D in Arctic marine transportation. This program was developed through the coordinating efforts of the Interdepartmental Panel on Transport R & D, under Transport Canada chairmanship. The objective of the program is to permit Transport Canada, the Department of Environment and the Department of Fisheries and Oceans to establish appropriate regulations, and, in conjunction with industry, to develop more efficient and effective services to support safe year-round shipment of Arctic resources by the late 1980's or early 1990's.

The Department of National Defence carries out oceans S & T activities in relation to maritime defence; in 1982/83, expenditures on this work will amount to $5.3 million. The primary areas of interest include research in acoustics in the ocean environment, hydrodynamics and advanced structural analyses applied to the design and operation of vessels and vessel components, and engineering and materials science aimed at solving problems encountered in operational maritime activities. The department funds a material development program, almost totally in Canadian industry, including a large maritime component. The activities in this program, although defence-oriented, contribute to the civil sector through technology spin-off. For example, array processing equipment being developed to meet a defence requirement will have application in areas as varied as sea-bottom mapping and synthetic aperture radar technology. The department also operates a diving research facility at the Defence and Civil Institute of Environmental Medicine in Toronto; this facility is designed to simulate water depths to 1700 meters for research on diving and undersea technology development.

The Natural Sciences and Engineering Research Council has identified "Oceans" as a Strategic Grants area, in recognition of the national importance of oceans science. Grants in this field are expected to amount to $3.3 million in 1982/83.

Scientific and Technical Information

As shown in Table 3:13, in 1982/83 the departments and agencies of the federal government will spend $196.1 million on scientific information services, reflecting the importance of scientific and technical information (STI) as a basic ingredient of scientific activity and of economic development itself. The greatest expenditures in this area are made by the National Research Council, the National Library, and the Departments of the Environment and of Fisheries and Oceans.

As a resource accumulated from contributions made all over the world, STI is most useful to countries that both collect it and develop appropriate systems to deliver it to those who use it. The Canadian scientific and technical community appreciates the importance of STI and is accustomed to drawing on the world's S & T literature through science libraries and special systems and services.

Foremost among such resources is the Canada Institute for Scientific and Technical Information (CISTI), which holds Canada's largest collection of STI. The institute is a Division of the National Research Council. It has a primary responsibility for providing national STI services and related support, and has been specifically charged with building up a national network of STI services. In developing this network, NRC has the support of its Advisory Board on Scientific and Technological Information (ABSTI), which provides valuable assistance as a forum for policy development. The membership consists of 14 representatives drawn from industrial, academic and government information organizations and user communities.

As part of the National Research Council's establishment, which operates side by side with the Council's large multi-disciplinary research laboratories, the institute is ideally situated to serve its clientele in the industrial, university, and government sectors. In pursuit of this mission it has accumulated an outstanding collection of S & T books, journals, reports and reference works and data bases from world wide sources.

New techniques have been developed to facilitate access to the information collection of the institute and of cooperating institutions. An example is the pioneer computerized system for search and retrieval of biblio-

Table 3.13

Federal Expenditures for Scientific and Technical Information

Department/Agency	1980/81 S&T*	1981/82 S&T	1982/83 S&T
		(millions of dollars)	
Total	**143.4**	**166.2**	**196.1**
Consumer and Corporate Affairs	12.3	12.5	14.8
Energy, Mines and Resources	8.4	10.7	12.8
Environment (Total)	15.3	17.0	19.2
Atmospheric Environment Service	4.1	5.2	5.7
Environment Conservation Service	7.4	8.0	9.5
Fisheries and Oceans	9.9	9.3	10.3
National Library	16.8	21.0	25.7
National Research Council (Total)	19.5	23.5	27.1
Scientific and Industrial Research Program	5.1	5.2	5.7
Scientific and Technical Information Program	14.5	18.4	21.4
Public Archives	10.6	11.6	13.6
Regional Economic Expansion	—	0.5	5.1
Social Sciences and Humanities Research Council	5.1	5.5	6.2
Statistics Canada	14.1	18.8	21.3
Others	31.4	35.8	40.0

* By definition the category Scientific and Technical Information is a Related Scientific Activity and therefore contains no R&D. It is included in this section because of its importance and occurrence in many departments and agencies.

graphic references to the STI literature, CAN/OLE (Canadian On-Line Enquiry System). This system now has a special feature whereby a client at a computer terminal anywhere in Canada can request from the institute a copy of any of the millions of documents referred to in current lists and data bases. To ensure fast response to user's requests, a bulk delivery service has been established using air courier to transfer needed documents to major centres across Canada. A new Canadian Scientific Numeric Databases (CAN/SND) service has recently been introduced. This service is designed to assist scientists and engineers to obtain and interpret critically-evaluated data.

In line with the government's concern to foster economic development, particular emphasis is placed on delivery of STI to Canada's industrial sector. Service to these very important clients forms a major portion of the institute's workload and accounts for about 45% of all loans and photocopies made and 55% of the requests received for literature searches on specific topics. Overall, the institute received more than 275,794 requests for documentary information in the year 1980/81.

The National Research Council also has a Technical Information Service (TIS), which operates rather like an agricultural extension service, but is oriented to the needs of small and medium manufacturing businesses with few or no technical staff or resources of their own. Through a network of field offices, many operated in conjunction with provincial organizations, the Technical Information Service provides technical information to help solve their manufacturing problems, and to improve productivity, to identify opportunities resulting from technological developments, and to promote the use of research results in industry. With more than three decades of operating experience, TIS has become a model for similar schemes in a number of other countries. Further details about the Technical Information Services are given in the Extramural science expenditures (Industry) section and in the Major participants (NRC) section.

In Canada, a major responsibility for fostering research publications in science and engineering has rested with the National Research Council. NRC now publishes eleven primary research journals in the following disciplines: biochemistry, botany, chemistry, civil engineering, earth sciences, forest research, geotechnology, microbiology, physics, physiology and pharmacology, and zoology. The Department of Fisheries and Oceans also publishes a scientific journal, now entitled the *Canadian Journal of Fisheries and Aquatic Sciences*. All these journals are distributed internationally and have attained a high rank among scientific journals in the world. They publish articles originating in Canada and also receive contributions from scientists and engineers throughout the world. Canadian journals act as a window on our own research and also provide a vehicle for the international exchange of such information.

Libraries are an important element in the provision of scientific information services across Canada. For example, Agriculture Canada has a network of over 20 branch libraries located across the country, at the hub of which is the headquarters library in Ottawa. There is also a well established cooperating network of university libraries across the country. Many scientific and special libraries in Canada have grown up over the years in response to institutional needs, and there is typically a great degree of cooperation and interdependence between them in matters such as interlibrary loans.

Examples of other federal S & T information activities include the development of source and bibliographic data bases to serve specialized needs, for example there are those provided by the Department of Energy, Mines and Resources in the fields of geophysics (National Gravity Data Base), geology (GEOSCAN), mining technology (MINTEC), mineral processing (MINPROC) and remote sensing (RESORS). Specialized S & T information services are provided by centres such as CANMET's Technology Information Division and the Canada Centre for Geoscience Data. Other examples include the Water Resources Document Reference Centre (WATDOC) and the Air Pollution Information Systems (both operated by the Department of the Environment) and the Defence Scientific Information Services of the Department of National Defence.

There are additional interesting examples to be found within the Water Pollution Control program of the Department of the Environment, such as the WATENIS and MUNDAT systems. WATENIS, the Water Effluent National Information System, provides an inventory of industrial and municipal water pollution sources including data on physical, chemical, and toxicological characteristics of effluents and information on water effluent regulations and guidelines. MUNDAT provides a data base covering municipal water works and wastewater systems from coast to coast, including data on federal facilities. It was developed in close cooperation with the provincial governments and the Federation of Associations on the Canadian Environment. The Ocean Dumping Permit System maintains an inventory and detailed information including the status of dumping sites for all permits issued.

Another specialized kind of STI service is provided by the Atmospheric Environment Service (Department of the Environment) which publishes each year more than 30,000 pages of climatic data in periodicals, single data sheets and statistical booklets. These highly-specialized STI services are supervised by regional climatological specialists who dispense publications, reports and documents, and provide analyzed information to a variety of Canadian users of the data.

Social Development

Science activities in the social development field within the federal government provide information for policy decisions over a wide range of areas: education, labour, manpower training and employment, population control, housing, consumer safety and health standards, community development, and social welfare. Consequently, several departments and agencies are involved in such activities, as shown in Table 3.14. Some goals of relevant policy initiatives are: improving welfare services; providing training for a more capable and flexible work force; increasing employment and improving the standard of living; measuring the implication of new technologies with respect to the economic security and safety standards of the work force; studying the growth of urban communities and their impact on transportation and housing.

Research in economics, sociology, education, demography, anthropology and other social disciplines has made a significant contribution toward the analysis of issues facing Canadian society. For example, problems linked to unemployment among youth and skilled manpower have been extensively studied. Nevertheless additional disciplinary research is needed to anticipate social tensions and diminish their consequences.

Within the Department of Labour, the Research and Development Division serves as the planning center for investigating, advising on and making recommendations on approaches to programs and policies related to conditions of work. Departmental expenditures in 1982/83 for S & T activities related to social development are estimated to be $4.7 million. The department's Financial Assistance Program for Labour Education was introduced in 1977 as one of its new initiatives aimed at improving the structure and process of labour-management relations. The broad objective of the program is to provide current and potential union officers and other members of labour organizations with opportunities to gain a comprehensive knowledge of the labour movement and its relationship to Canada's economic, political and social framework, and to achieve a more equitable distribution of the public funds made available for educational purposes.

Table 3.14

Federal Science Expenditures on Social Development

Department/Agency	1980/81 S&T*	1981/82 S&T	1982/83 S&T
	(millions of dollars)		
Total	**35.2**	**40.1**	**42.6**
Canada Employment and Immigration Commission	7.8	9.3	8.1
Employment and Immigration	9.5	9.6	10.2
Indian and Northern Development	—	0.4	0.4
Labour	3.8	4.2	4.7
National Health and Welfare (Total)	6.5	7.6	8.6
Administration Program	2.9	3.9	4.2
Health and Social Services Program	3.3	3.4	3.8
Secretary of State	3.0	3.1	3.7
Statistics Canada	2.8	3.6	4.1
Others	1.8	2.3	2.8

* This application area does not involve R&D in the Natural Sciences

The Quality of Working Life (QWL) program, which was launched by the department in early 1978, is concerned with the promotion of conditions within Canadian work organizations that are supportive of organizational change based on QWL principles, increased worker participation in workplace decision-making and joint endeavours by managers, unions and employees to resolve workplace problems and effect improvements in the general environment within which work is performed. Work restructuring, job redesign and improvements in occupational health and safety and other aspects of the work environment are major program dimensions.

The provision of financial assistance in direct support of project implementation within external organizations is now the dominant program emphasis. The development and maintenance of supporting national and regional networks of specialized QWL resource personnel who can provide third party assistance in project implementation within firms is one of the functions of the program's research and development arm. Related activities have included the conduct of national and regional conferences and workshops and funding to facilitate education and training activities.

Since the program commenced, awareness of QWL values has greatly increased, some viable supporting networks have been established and the number of regional QWL Centers has expanded. The number of QWL applications within organizations as well as union interest and support have continued to grow. Significant events during the 1981/82 fiscal year included the staging in Canada in September 1981 of the first International Conference on QWL (approximately 1700 participants from Canada and abroad) and the formation of the Canadian Council on Working Life.

With estimated S & T expenditures in 1982/83 of $10.2 million, the Strategic Policy and Planning Group in the Department of Employment and Immigration studies the dynamics of unemployment, participation patterns and the labour market problems of disadvantaged groups including women, native peoples, older workers and the disabled. It also develops the necessary infrastructure for re-examining immigration selection criteria to improve the achievement of key immigration objectives including a more effective management of immigration levels, maintaining a balance between different classes of immigration and an improved relationship between occupational demand and the skills of immigrants to Canada. Departmental research on the transitional costs to industry and labour of the current reindustrialization process has developed along two lines. First, in order to minimize anticipated economic dislocation proceeding from future labour market imbalances and bottlenecks, the department continues to refine and extend its comprehensive occupational forecasting program to anticipate possible critical skill shortages in both the near and the more distant future. Particular emphasis is being given to improving the match between the supply of and the demand for critical skills on both an occupational and a regional basis. To complement this forecasting effort, the department is engaged in a series of special labour market studies on specific occupational groups such as trades, health, engineering technicians, communications as well as industrial and sectoral analyses in the energy and microeconomics fields and in other high growth areas of the economy.

A second research focus has been to ascertain the quality of human resource planning in the private sector with a view to enhancing the effectiveness of recruitment, training and manpower planning mechanisms in maximizing the availability of labour for present and future needs. A comprehensive review of the issues was completed recently by the departmental Task Force on Employment Development. This body is currently undertaking supplementary research on a range of policy and program initiatives; these will enhance private sector and departmental capacity to develop in common a labour supply adequate to the challenge of reindustrialization.

The objectives and operations of the Unemployment Insurance Program within the Canada Employment and Immigration Commission are also regularly analysed and assessed in terms of their significant implications for labour market dynamics and for Canada's social security system. As the first phase in aligning program orientations, criteria and design features more closely to anticipated demands on the system in the 1980's, an incisive review of the program's policy underpinnings and logic was recently undertaken by the Unemployment Insurance Task Force. Supplementary studies on identified problem areas for program development are in progress.

The part to be played by immigration in meeting manpower objectives will be assessed with particular attention to demographic and cultural issues. For example, attention will be given to the identification and analysis of the major social and cultural factors underlying the adaptation of immigrants. Among other things, a survey of the Indo-Chinese refugees is in progress in order to study their economic and social adaptation to life in Canada.

In the Department of National Health and Welfare, the scientific activities addressing social welfare will cover a number of special populations and areas. They will include the development of research associates in the voluntary sector together with establishment of research teams and groups to work on specific themes such as the dynamics of single parenthood, the young single mother and her child, and the elderly. In addition, support will be directed to improve the training opportunities for social welfare management and to develop social work training models relative to the particular needs of Native People. Greater attention will be given to disseminating research results and new information derived from project activities, through publication of monographs, national and regional conferences and workshops.

In addition to the nearly $4.2 million in contributions covering the above activities, the Social Services Programs Branch of the Department also contributes $3.8 million to external R & D and related scientific activities through the Bureau on Rehabilitation ($0.2 million), which will be pursuing research related to the deinstitutionalization of the handicapped and their integration into the community; the Vocational Rehabilitation of the Disabled Program ($0.1 million), which will direct its fund to research on vocational rehabilitation matters; and the Canada Assistance Plan ($3.5 million), which will support the development of R & D activities and related infrastructures of provincial departments of welfare.

The Administration program of the Department will be providing $185,000 to the Institute of Social and Economic Research at the University of Manitoba, which was formally opened in 1981 and which conducts interdisciplinary research on current and emerging social and economic issues. Also transferred to the Institute, for further research and analysis, was the mammoth data-base generated during the seven years of the Mincome Manitoba guaranteed annual income experiment. It is expected to provide research material for years to come and permit exploration of such questions as the effect of guaranteed annual income programs on family stability or on work incentive. The program also provides technical and financial support to assist the provinces in developing effective social service management information systems. The program maintains statistical descriptive material of both health care delivery and social welfare systems, available through regular publication and on special request.

Scientific activities related to social development and welfare in the Department of Indian Affairs and Northern Development support the variety of missions and mandates which it has. These activities are estimated to require $0.4 million in 1982/83.

The Northern Affairs Program undertakes scientific endeavours in many fields in order to meet its legislated mandate to foster knowledge of the North. This work is accomplished through the Northern Scientific Training Grants Programme, the Northern Scientific Resource Centres Programme, and core funding to the Association of Canadian Universities for Northern Studies. In addition, the Northern Program undertakes scientific activities in respect of: the social, economic and political development of the North, projects relating to the transportation of hydrocarbons in the north, environmental assessment and management, and northern socio-cultural processes.

South of 60°, other components of the department (Indian and Inuit Affairs Program and Corporate Policy) focus their scientific activities on improving the social and economic conditions of Indians on reserve, on protecting Indian communities from environmental hazards, and on supporting the process for the resolution of Indian land claims.

Space

This evolving area of scientific and technological application embraces two distinct kinds of scientific activity: space technology, i.e., the development of satellite systems for various service applications, and space research itself, such as upper atmosphere research, planetary research, cosmology and research in astronomy.

On December 9, 1981, the Honourable John Roberts, Minister of State for Science and Technology, announced that the government would continue to give high priority to the development of the nation's Space Program and will spend $476 million on space during the period 1981/82 to 1984/85. The priority areas identified in the space plan are: communications and remote sensing applications, space science, and technology development. The major new initiatives include:

- participation in the Large Satellite Program (L-SAT) of the European Space Agency;

Table 3.15

Federal Expenditures on Space Science and Satellite Technology

Department/Agency*	1980/81 S&T	1980/81 R&D	1981/82** S&T	1981/82** R&D	1982/83** S&T	1982/83** R&D
			(millions of dollars)			
Total	**59.0**	**58.4**	**64.1**	**63.5**	**56.6**	**55.7**
Communications	36.7	36.7	38.9	38.9	29.4	29.4
Environment	2.0	2.0	2.2	2.2	2.4	2.3
National Research Council	18.5	18.0	21.1	20.5	22.5	21.7
Others	1.8	1.7	1.9	1.9	2.3	2.3

* Directly-related S&T expenditures by other departments and agencies in 1982/83: National Defence, $6.7 million.

** Does not include new resources involved in the new Space Program announced on December 9, 1981 by the Minister of State for Science & Technology.

- Phase B of the MSAT Program;
- continuation of RADARSAT studies;
- participation in the Phase B of the European Remote Sensing Program (ERS);
- several programs that will increase benefits to Canadians of the data obtained from remote sensing satellites;
- continuation of the Space Science Program;
- a technology development program aimed at developing and maintaining an up-to-date technological base in industry;
- a subsystem development program; and
- additional R & D support to the Canadian space industry.

The largest federal expenditures in this area are those of the Department of Communications, the Department of Energy, Mines and Resources, and the National Research Council.

Since 1969, the government's activities in space technology have been coordinated by the Interdepartmental Committee on Space. In 1980, the committee prepared the first five-year space program plan. In this plan, departmental and agency proposals were reviewed and, where possible, ranked in terms of relative priority and their relations to the achievement of national goals. In 1980, the responsibility for the committee was transferred from the Department of Communications to the Ministry of State of Science and Technology.

The major objectives of Canada's space policy are to ensure:

- that space activities meet national goals and service needs;
- that a viable, competitive space industry in Canada be developed and maintained; and
- that there be underlying research and development both to contribute to the knowledge of the properties of space and to assess the potential applications of satellite systems.

The utilization of space technology in the achievement of national goals occurs through activities proposed and budgeted by departments and agencies in accordance with their established mandates. In support of the objective of achieving a competitive Canadian space industry, there is a deliberate policy of transferring government space activities to industry and a purchasing policy which favours Canadian supply and deployment of satellite systems, with the exception of a launching capability. Canada will continue to procure its launch vehicle requirements for satellites from other nations. Thus, another element of our space policy is that Canada seek opportunities for cooperation and participation in the space programs of countries with launch facilities.

From the very inception of its space program, Canada has pursued a policy of international cooperation through agreements negotiated with other countries for all its major projects e.g., Alouette, ISIS, HERMES, RMS, LANDSAT, SARSAT AND L-SAT. This approach has been very successful in reducing the costs of the programs, in forging international scientific and technological links that provide Canada with technology not otherwise available and in creating opportunities and economic benefits for our industry.

The policy recognizes that Canada's ability to use space technology will be improved significantly by supporting underlying research into the nature of space, the search for potential applications, and technology programs which develop industrial capability to meet future requirements for operational satellite systems. Our use of space technology will also be strengthened by participating in international activities for the use and regulation of activities in space, negotiating agreements for continuing access to science, technology and required facilities, and maintaining knowledge of foreign space activities, in order to respond quickly at the national level to opportunities and threats to national sovereignty.

Since satellite technology is particularly suited to the solution of some distinctly Canadian problems originating in our severe climate, vast land and coastal area, and dispersed population, Canada has been involved in satellite development for two decades. It was the third nation to have its own domestically-developed satellite in orbit. Our satellite development activities aim at improving and developing communications, weather forecasting and surveillance systems, supporting search-and-rescue missions and supporting space-related scientific research.

During the past decade an increasing number of agencies have used satellite systems to supply operational services. The Departments of National Defence and of Transport will be using in 1982 satellite systems for search and rescue notification. This program, called SARSAT/COSPAS, is a joint Canada-France-U.S.-U.S.S.R. project. The Department of National Defence is providing most of the Canadian funding for SARSAT and is also involved with the U.S. in the development of the NAVSTAR satellite-based global positioning system.

The Canada Centre for Remote Sensing (Department of Energy, Mines & Resources) is receiving and processing data from LANDSAT satellites for application in agriculture, forestry, water resources, ice reconnaissance and oil and mineral exploration. Satellite imagery is being used by the Geological Survey of Canada to provide information on management of sediments in tidal zones of the Bay of Fundy.

The U.S. LANDSAT system gives information about the earth's surface, which is being found to be increasingly valuable for crop inventory, forest and wildlife management, water resource management, land use mapping, ice reconnaisance, and mineral and petroleum exploration. Canada has participated in this program by providing Canadian earth stations for the reception of LANDSAT data. LANDSAT-D, which is expected to be launched by NASA in 1983, will provide color and spatial resolution (30 instead of 80 metres) and, consequently, more detail and improved identification. The Canadian earth stations in Prince Albert, Saskatchewan, and Shoe Cove, Newfoundland will be modified to receive this high resolution data.

Furthermore, to meet with a high demand from user groups:

- a data processing system, named MOSAICS, for correction of remote sensing imagery will be developed; and
- the first phase of TOPAS, a program designed to provide a more comprehensive data base for resource and environmental management systems in the country, will be conducted.

The Atmospheric Environment Service (Department of the Environment) receives data and images of the earth and its atmosphere from operational and research meteorological satellites operated by the USA, such as NIMBUS and TIROS. In order to employ the data thus received in a quantitative way so as to improve the accuracy of the forecast of weather, ice and other environmental parameters and to increase the effectiveness of the total data acquisition system of the Service, certain systems and techniques will be developed. These include:

- development of a system to combine satellite images with data from a weather radar to provide short-term precipitation and severe-weather forecasts;
- research and development of methods of converting radiances measured by polar-orbiting satellites into information on the structure of the atmosphere, thus reducing the dependence on sounding balloons;
- completion, installation, and verification of the ice status system, and its extension to the mapping of snow cover and sea surface temperatures; and
- research to verify the capabilities of promising microwave space instruments for the measurement of ice and snow cover, ocean-surface wind, and surface temperature.

The interdepartmental SURSAT program was established in 1977, to determine the feasibility of using satellites to assist in meeting surveillance needs for the period 1980 to 2000 over the 200-mile coastal zone. These needs include daily all-weather monitoring of sea ice, wind and sea state, ocean pollution, ships, oil rigs and navigational aids. The project included participation in the U.S. SEASAT-A experiment, a proof-of-concept satellite carrying an advanced radar sensor known as Synthetic Aperture Radar (SAR), a complementary airborne research and development program, and consultation with potential international partners regarding a possible future joint operational system. The program, which included experiments involving over 100 prospective users, has demonstrated the SAR's effectiveness for monitoring ice and sea conditions and some capability for monitoring shipping. It has confirmed Canada's determination to move in support of Arctic petroleum operations, for which ice reconnaissance unhampered by cloud, fog or darkness is a critical requirement.

The SURSAT program has also produced sizeable industrial benefits. As a result of the program, the Canadian survey industry now has access to one of the best airborne radar systems for civilian purposes in the world.

The next step involves the development, in cooperation with Canadian industry, of a strong R & D program in the critical areas of radar satellite technology and its applications, particularly to ice-reconnaissance in support of Arctic oil, gas, mineral and other operations. The first phase of the RADARSAT program will define in detail the elements, costs and risks associated with the development of the space and ground segments of a SAR satellite system which will be a major component of a surveillance satellite program to be undertaken nationally or with chosen partners.

The Department of Communications is one of the largest funders of space science and technology. In addition to pursuing its mandate, the department also provides technology support to other departments in meeting Canadian needs in the design, development and construction of Canadian satellite systems.

The Department of Communications is entering the engineering definition phase of a multipurpose satellite (MSAT) system for use in mobile communications services for civilian and military users, particularly in the rural and remote areas of Canada.

In its technology development program, the Department of Communications identifies and develops satellite and communications systems technology necessary to meet Canada's needs in space telecommunications. Most projects are carried out in cooperation with Canadian industry or universities under the department's Industrial Contract Fund and other contracts from the department's operating budget. Projects in this program include the development of earth terminals and satellite technology (transponders, antennae and component development) for super-high-frequency communications, and spacecraft power systems technology, including spacecraft battery management. The control of spacecraft attitude is also being investigated, in particular satellite and antenna control and pointing.

The Department of Communications is also using Telesat's ANIK-B Satellite to determine the viability of new telecommunications services by means of pre-operational projects. The aim of these projects is to develop expertise in user institutions to better utilize 12-14 gigaherz satellite technology. Approved pilot projects include community communications, tele-education, tele-health, and public service communications.

In the foreign sphere, an Agreement of Cooperation between Canada and the European Space Agency (ESA) came into force on the 1st of January, 1979. It provides for contributions to ESA's general studies program and fixed common costs. Contracts have been awarded in general studies and basic technology to Canadian industry. The latter will participate in the design and manufacturing phases of the L-SAT, a multi-purpose satellite platform development and demonstration program.

The second broad category of government space activity, space research, is managed entirely by the National Research Council. Canada's last scientific satellite, ISIS II, which involved both NRC and the Defence Research Board, was launched in 1971. A new cooperative space science program has been negotiated with NASA and approved by the government in 1980. Its objectives are:

- to sustain and improve Canadian research competence in the space sciences;
- to provide a significant fraction of new knowledge needed by Canada to base decisions on the future use of space; and
- to train young scientists and engineers in a variety of space disciplines of interest to Canada and to share with NASA the generation of new knowledge.

To rationalize its space research activities, the council created, in August 1980, a new organizational unit named the Canada Centre for Space Science (CCSS).

The programs carried out by the centre will include the existing rocket and balloon program aimed at providing a better understanding of the earth's space environment at altitudes in the neighbourhood of 100 km., and a new international program of some $42 million over the next 6 years. The program will allow Canadian scientists from government and university science to investigate the properties of plasmas and winds in the space environment of the earth and will involve the development and construction in Canada of a number of major new instruments which will be flown on the U.S. Space Shuttle around 1985. This program will also allow the Council to respond more effectively to "Announcements of Opportunity", from both NASA and from other foreign agencies. For example, the centre will participate in the VIKING experiment, the first Swedish scientific satellite, by supplying an ultraviolet imager.

Among its operations for 1982/83, the centre plans to conduct two rocket experiments which will involve the release of chemicals in the ionosphere, at a combined estimated cost of $1.1 million. One of the experiments will use of barium vapor cloud, as a visible tracer to study the magnitudes and orientations of electric fields at altitudes around a few hundred kilometres. The other project, called Waterhole III, will release about 200 kgm of water above an auroral display, in order to study the observable effects of the resultant depletion in plasma density. This experiment will be an attempt to extend the knowledge gained from the previous Waterhole I and Waterhole II flights of 1980/81 and 1981/82, as well as to answer some of the questions raised by these earlier experiments.

Most of the large satellite projects of recent years, such as the Remote Manipulator and the HERMES and ANIK-B, C and D satellites have been, or are, in the process of being completed. To fulfill the national space mandate, and to maintain continuity in space activities, some new R & D projects, such as MSAT (phase B) and RADASAT (phase A), have been approved and others are being considered.

Transportation

Since transportation is involved in many activities and responsibilities of the government, transportation-related scientific activities are conducted by Transport Canada, by the Department of Fisheries and Oceans, by the National Research Council and other departments, as shown in Table 3.16.

Table 3.16

Federal Science Expenditures in Transportation

Department/Agency*	1980/81		1981/82		1982/83	
	S&T	R&D	S&T	R&D	S&T	R&D
			(millions of dollars)			
Total	**67.5**	**38.3**	**73.1**	**43.5**	**83.2**	**53.1**
Energy, Mines and Resources	2.1	2.0	0.8	0.7	1.0	0.9
Fisheries and Oceans	23.9	11.9	24.5	12.2	27.4	12.3
National Research Council	18.4	18.4	20.6	20.6	24.5	23.4
Statistics Canada	3.0	—	3.2	—	3.7	—
Transport Canada (Total)	16.1	5.0	19.5	8.4	21.6	14.9
Administration Program	5.0	3.3	7.5	5.0	8.2	5.3
Air Transportation Program	2.4	0.3	2.8	0.6	3.2	1.0
Marine Transportation Program	8.5	1.3	8.9	2.8	9.9	8.4
Surface Transportation Program	0.1	—	0.2	—	0.3	—
Canadian Transport Commission	2.8	—	2.7	—	3.3	—
Others	1.2	1.0	1.8	1.6	1.7	1.6

* Directly-related S&T expenditures by other departments and agencies in 1982/83: National Defence, $11.3 million.

Combined effects of demography, physiography, climate and resource distribution have been responsible for the evolution of the extensive and diverse transportation systems within Canada. Transport Canada's role is to attend to the development and operation of a safe and efficient national transportation system which contributes to the achievement of governmental objectives, and to operate specific elements of the system.

Technical research and development is one of the means by which deficiencies and inefficiencies can be rectified. A major consideration in the resolution of transportation requirements is the current state of existing systems and the major capital expenses planned for new systems. Consequently, upgrading and incremental improvements by application of modern technological advances is a major objective of the science activity. To fulfill its role, Transport Canada requires up-to-date incremental improvements by application of modern technological advances, and this is a major objective of the science activity. To fulfill its role, Transport Canada requires up-to-date expertise which can recognize and assess the potential of technological advancements for incremental improvements to mature, highly-developed transportation systems, and at the same time can assist and encourage the introduction of new concepts and designs when modification of existing systems is considered uneconomical or insufficient to meet requirements. Among the related scientific activities, data gathering is important for the accurate assessment of existing transportation capabilities, for the prediction of future requirements and for the establishment of the optimum methods for achieving goals.

The coordination and planning of research and development activities and programs are carried out by the Interdepartmental Panel on Transport Research and Development, (TR & D) which is chaired by Transport Canada's Assistant Deputy Minister of Strategic Planning. Special emphasis is given to problems of particular importance to Canadian transportation and to the adaptation of known techniques to satisfy Canadian conditions. To date, plans have been prepared by the Interdepartmental Panel in the priority thrust areas of Arctic Marine, Rail Freight and Urban Transportation. Under Transport Canada sponsorship, Arctic Marine and Rail Freight TR & D plans were presented to the federal cabinet which approved a $14.0 million increase in these two areas. Over the next three years, about 2/3 of this new money will be spent on Arctic Marine TR & D with the other third on rail freight TR & D. The bulk of the R & D will be contracted out to industry, scientific and technological agencies all across Canada.

Arctic funds will be spent by Transport Canada, Environment Canada and Fisheries and Oceans on:

- development of improved navigation, ice forecasting and iceberg collision avoidance technology;
- improvements of steel, new hull, propeller and power-plant design required for year round Arctic operation;
- study of sea ice and ocean conditions in Arctic shipping lanes;
- improvement of equipment and standards to minimize environmental impact and to combat spills.

Funds for railway freight R & D will be spent by Transport Canada and will go towards:

- further computerization of railway control operations;
- development of lighter locomotives and more fuel-efficient locomotive engines;
- alternative fuels for railway operations, including electrification;
- steerable rail car trucks, improved braking systems, and multi-modal terminals.

These two augmented R & D programs mark the first step in Transport Canada's renewed commitment to a higher national effort for transportation R & D. Transport Canada is determined to reverse the present trend towards lower transportation productivity caused by escalating energy costs and a slower pace of technological advance. They are in line with the government's policy commitment of January, 1981 for an R & D expenditure target of 1.5 per cent of the gross national product by 1985.

The expected results of these two programs and others being developed through Interdepartmental Panel on TR & D working groups in priority thrust areas such as pipelines, safety, energy, highways and possibly aeronautics will meet both transportation technological needs and opportunities and increase significantly the capability of Canadian industry to produce and sell advanced technology transportation equipment in domestic and international markets.

The majority of Transport Canada's R & D activities for 1982/83 -estimated expenditures of $24.0 million— are mostly of an ongoing nature, in support of operations, and include activities funded under the new

Arctic Marine and Rail Freight R & D programs. R & D work in the marine mode involves the updating of navigation aids; improvement to the handling capacity of the St. Lawrence Seaway; development of improved navigation, ice forecasting and iceberg collision avoidance technology; improvements in steel, new hull, propeller and power-plant design required for year round Arctic operation; study of sea ice and ocean conditions in Arctic shipping lanes; and improvement of equipment and standards to minimize environmental impact and to combat spills. In the surface mode, transportation work is continued on those aggregated projects recommended by the Rail Advisory Committee and on work done in road safety. New work is being initiated to further computerize railway control operations; to develop lighter locomotives and more fuel-efficient locomotive engines; to develop alternative fuels for railway operations, including electrification; and to design steerable rail car trucks, improved braking systems, and multi-modal terminals. In the air mode, R & D activities is undertaken to incorporate new developments into communications, air traffic control methods, navigation and airport productivity. Transport Canada is also involved in a number of R & D programs, across all modes: safety, energy efficiency in transportation, liquid fuels and transportation of energy commodities as well as in the transportation, storage and transfer of hazardous commodities.

In the Department of Energy, Mines and Resources, the Minerals and Earth Sciences Program is involved in providing advice on construction requirements and routing of land transport systems. It is also involved in R & D concerned with fabrication techniques and structural materials with characteristics suited to the many needs of transportation, such as: lighter weight materials and alloys for vehicles, rail and wheel materials with improved wear characteristics, and steels for oil and gas pipelines. The transportation of coal slurries in pipelines is taking on increasing importance in R & D.

The Atmospheric Environment Service of the Department of the Environment is carrying out a program of research and development aimed at improving the weather, sea state and ice information services available in the Arctic. This program, part of the Government Energy Transportation Program, is designed to provide future operations with the environmental information and forecast necessary to operate in the most effective and economic manner. This is of great importance in the Arctic when the costs of engineering around all possible environmental obstacles could make the entire venture unfeasible. High-quality forecasts can provide the lead time necessary to minimize risks and select the most economic routes. The Atmospheric Environment Service is working to develop improved aerial remote sensors for ice reconnaissance. Implementation of more powerful laser profilometer is nearing completion, a data "down-link" system is being developed, and investigations into automated data analysis are continuing.

With estimated spending in transportation science in 1982/83 of $27.4 million, the Department of Fisheries & Oceans provides marine data services; in particular the charting of inland and ocean waters is required for marine navigation.

The National Research Council is a major contributor to research and development in all aspects of transportation engineering through its maintenance of national facilities and the interaction of diversified scientific personnel. The council plans to spend $24.5 million in this area in 1982/83. These expenditures cover work in diverse areas such as ice-breaking or iceberg towing with the object of devising methods, for example, of keeping icebergs away from drilling rigs operating in the Labrador Sea's notorious "iceberg alley", a treacherous but promising zone for oil exploration.

Currently a major program of the council's Marine Dynamics and Ship Laboratory is concerned with establishing the Arctic Vessel and Marine Research Institute (AVMRI) on the grounds of Memorial University in St. John's, Newfoundland. The new institute will evolve from the laboratory's present facilities now located in Ottawa. This entails the planning, design and construction of the new laboratory, recruiting and training of its personnel, which will be drawn both from industry and from within the council, and adaptation of the Ottawa laboratory's projects to allow a smooth transition when the St. John's laboratory starts operating. Because continuity with the existing Ottawa program is considered important, the research program for the Marine Dynamics and Ship Laboratory is being determined in consultation with the new institute's Advisory Committee, which has representatives from industry, Memorial University and the federal government. The conceptual design of the new institute is now complete, and work has begun on detailed design and construction. In 1982/83 an additional $16.3 million will be spent thus representing a total expenditure to date of 37% of the total capital cost of $55.6 million for this project.

Much of the council's work in transportation is carried out in cooperation with other agencies, such as the Transportation Development Centre of Transport Canada. For example, in collaboration with the Transportation Development Centre (Transport Canada), the council is investigating technical feasibility of utilizing superconducting electric motors for the propulsion drives of the Arctic icebreaking bulk carrier and of the Coast Guard vessel designs, currently being proposed by Petro-Canada and Transport Canada.

With its newly improved test facilities, both in Ottawa and Vancouver, the council's Division of Mechanical Engineering continues to aid railway operators and users, car builders and government regulatory agencies by providing instrumentation and facilities for testing existing and proposed methods and equipment. These facilities include a one million pound compression squeeze frame for full sized cars, a ramp track for generating strength-proving impacts, a self-contained instruments caboose and a collection of track-side, over the road, and laboratory measuring equipment. These facilities have been in continual use by industry for some years.

The Department of National Defence cooperates with Transport Canada by providing some facilities and technical support to the Road Safety Unit at the Defence and Civil Institute of Environmental Medicine in Toronto and by conducting anthropometric and human engineering studies related to vehicles.

Work on vehicle mobility is under way at the Defence Research Establishment Suffield in Alberta and studies in terramechanics, terrain analysis and over-snow mobility have recently been initiated. A number of other defence projects can be considered as transportation-related; these cover such diverse fields as search-and-rescue (because of the implications for transportation safety), ship reliability studies, marine propulsion and vehicle batteries. The Defence Research Establishment Atlantic in Halifax conducts research in ship design including ship dynamics and stability, propeller performance, ship structural mechanics and predictive design methodologies. The Department of National Defence is also represented on the Interdepartmental Committee on Transportation R & D.

4. Extramural Science Expenditures

Introduction

Extramural S & T activities are those activities funded by the federal government but performed in the business sector, universities, other levels of government or other countries. In addition to funding of extramural activities as a means of stimulating S & T activities in the private sector, the government also attempts to create an enhanced capability for innovation through tax, tariff, patent, competition, trade and special procurement policies and special transfer payments to the provinces. The government's extramural expenditures classified by performing sector are shown in Table 4.1

Since 1978 the government has pursued a renewed policy of strengthening the R & D capacity of the country, primarily in the extramural sectors and particularly in industry, with a target of increasing Canada's Gross Expenditures on R & D (GERD) to a level which approaches those of other industrialized countries. Earlier initiatives to enhance GERD have included: increased tax incentives; improved procurement policies; enhanced technology transfer from government science to industry; improved interfaces among government, industry and university laboratories; science and technology employment initiatives; and further enhancement of university research in areas of national concern.

Within the Canadian science system, it is in the universities that our capacity to undertake basic research has been developed and is located. The need for new knowledge cannot fully be met without investment in university research. This research is also the principal means of training research manpower in Canada. As a consequence the universities are the very core of the Canadian science effort.

The magnitude of the increase in Canadian R & D being sought implies requirements for a major increase not

Table 4.1

Federal Extramural Science Expenditures

	1980/81		1981/82		1982/83	
	(millions of dollars and (%))					
Total	**770.3**	**(100)**	**986.1**	**(100)**	**1,132.7**	**(100)**
% of Total S&T	*36%*		*38%*		*39%*	
Industry	306.1	(40)	417.1	(42)	482.9	(43)
University	320.0	(42)	390.3	(40)	441.2	(39)
Canadian Non-Profit Institutions	22.5	(3)	27.0	(3)	31.2	(3)
Provincial and Municipal Governments	46.6	(6)	62.7	(6)	80.0	(7)
Foreign	57.5	(7)	67.5	(7)	75.1	(7)
Others	17.6	(2)	21.6	(2)	22.5	(2)

only in the supply of highly qualified manpower but also in the knowledge base, i.e., basic research. This in turn implies a strengthening of the university research system. For some years now the government has been strengthening the operations of its three main granting councils. On April 1, 1978, the Natural Sciences and Engineering Research Council and the Social Sciences and Humanities Research Council were formed to assume responsibility for the university research granting programs formerly operated, respectively, by the National Research Council and the the Canada Council. The mandate of the Medical Research Council was also extended to permit support of research in health care. At the same time an Inter-Council Coordinating Committee was established to provide to the Minister of State for Science and Technology an overview of the councils' activities and advice on the allocation of funds.

The emphasis given to particular objectives and program elements has varied between the granting councils because of differing circumstances for their clientele but there are certain common features. First and foremost are proposals for increased support for the direct costs of research so as to maintain and strenghten the level and quality of university research, which is perceived to have been relatively neglected in the last few years. Considerable importance has been given to a long-term funding commitment by the government. This is considered essential for the success of the councils' programs because of the long time-frame involved in planning and conducting research, in training research manpower and in providing buildings and equipment. In general, considerable stress has been placed on continuing and expanding support for curiosity-oriented research. Nevertheless, substantial increases in funds have also been proposed for research in areas of national concern. Details of the specific programs of each council are discussed in the Major Participants section.

A major increase in the budget of the Natural Sciences and Engineering Research Council of Canada (NSERC) was announced in 1981. The council's initial budget of $181.5 million for 1981-82, which already included an increase of $18.9 million to cover cost increases, was further increased by an additional $20 million in mid 1981, to bring the council's total budget to $201.5 million, representing an annual increase of 23.9%. This increase was made to permit the council to maintain and expand important initiatives within its Five-Year Plan, which were begun in 1980. Coupled with the previous year's increase of $42 million, the council's budget has grown by some 67% over the first two years of its plan, or by 40% excluding allowances for inflation.

Implementation of the policy to strengthen interfaces between the government, industry and university sectors is proceeding. During 1978, the Government announced its intentions to fund university-based industrial research and innovation centres to aid industry, particularly small businesses and private inventors, in the development of new products or technologies. As a result, two industrial innovation centres, one at the University of Waterloo and the other at École Polytechnique de Montréal, have been established. It is expected that the centres will become self-sufficient over a seven year period.

As another means of encouraging R & D in Canada, a new procurement policy has been implemented whose objective is to obtain significant socio-economic benefits from government procurement. One of the subobjectives is to concentrate initially on industrial benefits, particularly in the electronic and other high technology sectors. In addition to fostering the development of high technology industries, the policy is expected to assist in improving export potential, stimulating new product innovation and improving production technology. In particular the policy permits, under certain conditions, the payment of extra costs or a premium for "buying Canadian". Among the criteria to be met for choosing a procurement alternative involving extra costs are:

- there are good prospects for commercial viability;
- the benefits justify the extra costs;
- the benefits would not be realized without government assistance;
- the procurement will contribute to the exploitation of a strategic opportunity.

Other initiatives in the procurement area included the establishment of a federal-provincial working group on Cooperation in Procurement Policy. The Department of Energy, Mines and Resources established an Advisory Committee on Industrial Benefits which, with provincial input, has been reviewing major capital projects in the energy development field with the objective of obtaining maximum Canadian industrial participation.

Concurrent with the increased emphasis on technology transfer, Canadian Patents and Development Limited has seen a considerable increase in the licensing of "know-how", particularly in areas of unpatentable or unpatented technology. This trend continues. In its more traditional patenting and patent licensing activities, the agency expects that some important scientific advances of the 1970's will be licensed in the early

80's, particularly in the fields of genetic engineering and energy.

Other measures to improve technology transfer have included an expansion of the National Research Council's successful Program of Industry/Laboratory Projects (PILP) and its consolidation with the similar program, Cooperative Projects with Industry (COPI) in some other departments. As one of a number of measures to improve access to government programs of industry support these programs were amalgamated in 1981/82. The point of contact is the National Research Council's Industrial Assistance Office, whose activities are described in more detail in the Major Participants (NRC) section.

Industry

The government's direct support of industry S & T activities is expected to reach $482.9 million, an increase of 15.8% over forecast expenditures of $417.1 million in 1981/82, and a 57.8% increase over 1980/81 expenditures. Data on departmental payments to industry to support S & T activities is given in Table 4.2. Data for the major support programs under which these payments are made are shown in Table 4.3.

In addition to contracting out mission-oriented S & T requirements and supporting technology transfer from its laboratories, the government also encourages and supports industrial R & D by means of contributions to companies for specific projects and by grants to universities, provincial research organizations and industrial associations for the provision of special research and technical services. The principle source of funds for the support of industrial research is the Industrial Research Assistance Program of the National Research Council; support for the later developmental phases is provided by the Enterprise Development Program, the Defence Industry Productivity Program and the Industrial Energy Research and Development Program of the Department of Industry, Trade and Commerce.

Major expenditures occur under the industry support programs of the Department of Industry, Trade and Commerce, which is the largest funder of government-supported S & T activities in the industry sector. Increased expenditures of $27.8 million to $155.9 million in 1982/83 for departmental payments to industry are provided for in the estimates.

The Enterprise Development program is a multi-purpose program incorporating several of the department's former programs. One of the broad range of industrial development tools comprising this program is support for introduction of new or improved products and processes which have the potential for profitable commercial exploitation. Companies in Canada which can demonstrate the need for financial assistance and the capability to pursue successful R & D projects are eligible for cost-shared assistance for process and product innovation and market research. Eligibility is generally limited to small and medium-sized businesses engaged in manufacturing or processing operations prepared to undertake relatively high risk projects which promise attractive rates of return and good prospects of success. Funding in the form of contributions is available for up to 75% of eligible costs of the following kinds:

- for research, development and design projects provided the project represents a significant burden on the company's resources; and
- to engage consultants for market feasibility studies, productivity enhancement studies, product development and design studies, and, pollution control and abatement technology development projects.

Projected science and technology expenditures under the program in 1982/83 are estimated to be $94.4 million, including $15.7 million under the Special Electronics Fund in support of the advanced electronics sector. Forecast S & T expenditures for 1981/82 are $80.3 million and expenditures in 1980/81 were $63.6 million.

The Microelectronics Support Program (MSP), a component of the Special Electronics Funds, is designed to encourage the application of microelectronics to all sectors of Canada's industry. Support is in the form of contributions for (1) feasibility studies, (2) project support and, (3) custom micro-circuit design. The department will bear the cost of approved studies up to a maximum contribution of $10,000, and may contribute up to 75 percent of eligible costs of approved projects

Table 4.2

Federal Science Expenditures in Industry

	1980/81	1981/82	1982/83
		(millions of dollars)	
Total S&T Payments to Industry	**306.1**	**417.1**	**482.9**
R&D Grants and Contracts (Total)	**240.5**	**341.9**	**394.3**
Natural Sciences (Total)	**237.2**	**337.3**	**389.3**
R&D Contracts (Total)	100.2	139.3	167.6
Communications	7.0	10.4	6.2
Energy, Mines and Resources	4.9	10.8	14.4
Atomic Energy of Canada Limited	7.7	11.2	12.2
Environment	9.6	10.5	9.9
Fisheries and Oceans	3.4	5.2	7.1
National Defence	23.0	29.7	47.1
National Research Council	23.9	38.6	40.1
Supply and Services (Unsolicited Proposals)	10.6	10.7	10.7
Transport	3.2	5.8	10.8
Others	6.9	6.4	9.1
R&D Grants & Contributions (Total)	137.0	198.0	221.7
Communications	9.2	11.7	2.3
Energy, Mines and Resources	16.3	16.3	11.6
Industry, Trade and Commerce	84.2	128.1	155.9
National Research Council	22.1	35.5	45.7
Natural Sciences and Engineering Research Council (Industrial Research Fellowships)	1.6	2.8	3.9
Others	3.6	3.6	2.3
Human Sciences (Total)	**3.3**	**4.6**	**5.0**
RSA Grants & Contracts (Total)	**65.6**	**75.2**	**88.6**
Natural Sciences (Total)	**55.4**	**63.2**	**74.7**
Energy, Mines and Resources	5.6	6.7	9.9
Atomic Energy of Canada Limited	12.6	12.4	14.7
Environment	1.4	1.6	1.5
Fisheries and Oceans	2.0	3.4	6.2
Canadian International Development Agency	22.4	24.6	27.1
Transport	3.7	4.1	4.1
Others	7.7	10.4	11.2
Human Sciences (Total)	**10.2**	**12.0**	**13.9**

to a maximum of $100,000. In conjunction with the MSP, the department has announced the establishment of microelectronic centres of technology at six Canadian universities, the overall objective of which is to encourage the manufacture of microelectronic devices and their application to all sectors of industry. Each centre will receive $1 million over a five-year period.

The Defence Industry Productivity (DIP) program assists high technology industry in several sectors including aeronautics and electronics. S & T expenditures under this program for 1982/83 are estimated to be $66.4 million compared with $55.9 million in 1981/82. Actual S & T expenditures in 1980/81 were $39.1 million. The program provides assistance for product development, pre-production expenses and capital costs on a shared basis.

Table 4.3

Federal Science Expenditures under Selected Industrial Support Programs

	1980/81	1981/82	1982/83
		(millions of dollars)	
Agriculture			
Production, Distribution, Retailing (PDR)	0.9	0.9	0.9
Environment			
Energy from Forests (ENFOR)	4.4	6.2	7.0
Industry Trade and Commerce			
Defence Industry Productivity (DIPP)	39.1	55.9	66.4
Enterprise Development (EDP)	63.6	80.3	94.4
Industrial Energy R&D (IERD)	1.5	1.5	7.0
National Research Council			
Industrial Research Assistance (IRAP)	20.7	25.4	33.7*
Industry/Laboratory Projects & Cooperative Projects with Industry (PILP & COPI)	9.6	16.4	16.8
Technical Information Service (TIS)	3.9	8.6	—*
Supply and Services			
Unsolicited Proposals (UP)	15.0	15.1	15.0

* As of April 1, 1982, IRAP and TIS are combined under one responsibility centre.

The Industry Energy Research and Development (IERD) program was established in 1977 to encourage industry to undertake R & D projects which had as their objective the conservation of energy in industrial processes. Under this program, the Department normally provided 50% of the costs of an R & D project undertaken by the industrial firm. During the first four years of operation, the program budget amounted to $1.5 million annually.

Because of the low level of IERD activity, changes have been proposed to the program which would broaden the assistance available to industry, and make projects with direct applications in the consumer market eligible for support. Under the new proposals, funding of the IERD would be increased under the National Energy Program (NEP) by $5.5 million, bringing the total program budget for 1982/83 to $7.0 million.

Other programs administered by the Department of Industry, Trade and Commerce assist in the establishment of non-profit organizations to provide R & D and other special technical services under contract to industrial and other clients. The Industrial Research Institute program assists in the establishment of organizations at Canadian universities which arrange for university faculty to provide contract research and technical services to industry; nine industrial research institutes are now in operation. The Centres of Advanced Technology program assists universities and provincial research organizations to develop and maintain a special competence in a specific field of technology and to provide, under contract with industry, assistance with development projects and training and evaluation services relating to that technology; twelve centres of advanced technology are now in operation. The Industrial Research Association program assists groups of firms to undertake cooperative research on common technical problems; four industrial research associations are now in operation. The budget for the three programs in 1982/83 will be $1.5 million, augmented by the Special Electronics Assistance mentioned above. Under these programs, the Department of Industry, Trade and Commerce supports individual institutes and centres for a maximum of 7 years, during which time they are expected to become self-supporting. Of the 21 centres and institutes established now in operation, 13 are now financially self-sustaining.

The National Research Council is the second largest funder of industrial S & T activities. Council payments to industry for 1982/83 are estimated to be $86.6 million, an increase of $11.5 million from 1981/82. Ninety-nine percent of the National Research Council's industrial funding is for R & D. It is divided between contracts ($40.1 million) and grants and contributions ($45.7 million). A significant part of the contracted R & D has occurred under the council's technology transfer mechanism known as Program for Industry/Laboratory Projects (PILP). This program has been amalgamated with the Cooperative Projects with Industry program and some funding can now be provided as contributions to cooperating firms. Under the combined programs, estimated expenditures in 1982/83 are $16.8 million, compared to forecast expenditures in 1981/82 of $16.4 million and 1980/81 expenditures of $9.6. million. The council's Industrial Research Assistance Program (IRAP) also provides grants. These programs are further discussed below, and organizational details are given in the Major Participants (NRC) section.

Under the PILP program, laboratory projects are contracted out to industry for further stages of development. This fosters closer cooperation between government scientists and those working in industrial R & D and it helps to further the development of industrial R & D in Canada. Moreover, projects whose development has occurred in industry are more likely to progress to the manufacturing and marketing stage than those developed entirely in government laboratories. Successful PILP projects include extraction of oil from tar sands; vertical-axis wind turbines for electrical power generation; a snow-and ice-free railroad switch; and reduction of hydrogen levels in steels.

The following are examples of the diversity of PILP's collaborative projects with industry. McDonald, Dettwiler and Associates Ltd. of Richmond, B.C. markets hardware and expertise in Synthetic Aperture Radar (SAR) signal processing. Its position of world leadership was attained with the help of the cooperative work of the council's Divisions of Physics and Electrical Engineering, the Computer Technology Research program and the Department of Energy, Mines and Resources, and was partially funded via a PILP contract. SAR technology permits high resolution imagery to be obtained independently of weather conditions, night or day. This capability is very important, particularly on Canada's fogbound coasts and during the long arctic night.

As a result of another PILP project, the council's Physics Division has contributed to the performance of SCIEX Corporation of Thornhill, Ontario. By use of the council's quadrupole mass spectrographic technology, this young high-technology Canadian company is now able to deliver the world's first fully engineered triple quadrupole mass spectrometer systems. These systems provide rapid, highly sensitive and discriminating analyses of traces of organic materials in complex mixtures.

Biotechnology has been constantly in the news in recent months. Through PILP, Canadian industries are being given a running start into this major industrial activity of tomorrow. About 20 projects in the biotechnology area are being funded at total level of about $23 million over several years. These projects are generally oriented towards the development, through genetic engineering techniques, of micro-organisms that can be used for the production of materials of commercial interest including human insulin and other pharmaceutically-important biological agents. In addition, IRAP provides a similar level of funding to industrial projects in this area.

The purpose of the Industrial Research Assistance Program is to assist in the development of R & D capability in Canadian industry, by awarding funds to cover the salaries and wages of R & D staff working on approved projects. Canadian companies engaged in projects with significant technical content are eligible. Reported expenditures are $25.4 million for 1981/82, and $20.7 million for 1980/81. The National Research Council estimates that a further $36.1 million will be spent in 1982/83 on other contracts and grants to industry. Beginning in 1982/83 expenditures for the Technical Information Service will be included within those reported for this program. The combined expenditures for 1982/83 are estimated to be $33.7 million. IRAP currently supports about 450 projects per year in over 350 companies, with the largest number being in the electrical and electronics, food and agriculture, and chemical sectors of industry. More specifically, the IRAP funds, which cover the salary component of R & D project costs, provided support in 1980/81 for over 660 professional and 420 technical person-years.

The following are examples of activities which have received IRAP support. A family of high solids polyester coating resins has been developed and evaluated for use in coil coatings and high temperature baked enamels by Ashland Oil Canada Ltd., a Mississauga, Ontario firm. The new formula has already met with wide acceptance in the market among a number of paint-producing concerns. Sales to such firms are expected to exceed $5 million per year.

Eastern Coated Papers Ltd., of Dorval, Quebec, established a research team to investigate the potential for manufacture of low-cost zinc oxide papers for electrostatic copying machines. Within three years the company had captured a significant segment of the market and entered the highly competitive export market with the product.

Other major funders of industrial S & T are the Department of National Defence with 1982/83 estimated expenditures of $47.2 million, the Department of Energy Mines and Resources with $36.7 million, the Canadian International Development Agency with $27.1 million and the Department of Communications with $10.2 million. The industrial funding by the Department of National Defence is almost 100% in the form of R & D contracts and represents about 85% of its extramural spending which in turn represents about 40% of its S & T expenditures. Payments to industry by the Department of Energy, Mines and Resources, are estimated to be $36.7 million in 1982/83, compared to $34.5 million in 1981/82 and $27.4 million in 1980/81. Most of the increase has been for additional work in energy R & D. All of the industry S & T funding by the Canadian International Development Agency, up $2.5 million from 1981/82, is for RSA, such as feasibility studies concerned with agricultural, industrial and commercial development projects in Third World countries.

Characterized by major satellite projects, estimated 1982/83 industry expenditures by the Department of Communications ($10.2 million) show a decrease of $13.8 million over 1981/82 expenditures, as a consequence of the natural ebb-and-flow of project funding. 1981/82 payments to industry, however, at $23.9 million were $6.5 million higher than those in 1980/81.

Masked by these project funding decreases is increased funding to assist industry in exploiting two major high technology opportunities. One concerns the exploitation of Telidon, a departmentally-developed videotex system. The industrial assistance being provided covers such activities as field trials, development of production prototypes, equipment standardization and related activities. Field trials are underway or planned by such organizations as Bell Canada, Alberta Government Telephone and the Manitoba Telephone System.

The other thrust concerns the office automation or "office-of-the-future" development by the department. A joint industry-government Office Communications Systems program has been approved, with government funding for direct program costs of $12.5 million over the life of the program. It is estimated that payments to industry for S & T activities in support of the program will be in the order of $4 million in 1982/83. The direct program expenditures on office automation by the department can be complemented by additional expenditures through the Department of Industry, Trade and Commerce's cost-shared programs such as the Enterprise Development Program and the Special Electronics Fund, and through normal office equipment procurement during the life of the program.

This program is being carried out in phases. Phase one, with a budget of $2.5 million is into the second year of its expected 2-year duration. Government and industry are working together to develop office communications systems, to organize field trials, and map out a detailed industrial strategy and to conduct technological, behavioral, social and economic research. Phase two, which is dependant on the success of the first phase has received approval in principle for funding up to $10 million. Expected to commence in 1982, phase two of the Office Communication Systems program will fund development of electronic office equipment for field trials in government offices and further research and product development.

Contractual links between government departments and Canadian industry are administered by the Science Centre of the Department of Supply and Services in its role as manager (on behalf of other departments and agencies) of science contracts with the private sector. The centre is also the focal point for consideration of unsolicited proposals for the conduct of scientific activities. In this connection the department manages an Unsolicited Proposals Fund, now totalling $15.0 million. This fund provides interim financing for acceptable unsolicited proposals from the private sector when a department is unable to fund the work from its current budget. Under special circumstances this mechanism can be used to fund all stages of the proposed work. From its inception in 1974, to the end of 1982/83, this fund will have provided a total of $99.6 million. For 1981/82 forecast expenditures are $10.7 million in support of mission-oriented R & D and $2.2 million for RSA in industry.

Although many of the R & D contracts in support of departmental missions implicitly aid in technology transfer, the government decided in 1978 that there should be a renewed emphasis given to the policy that technology transfer should be an explicit objective of all its laboratories. The intention is to encourage all government laboratories to identify at an early stage research that may be of possible industrial interest, and to plan for the successful transfer to, and exploitation by, industry of the results of the research.

There have been some significant technology transfers from government laboratories over the years: the development of a sizeable nuclear industry has been fostered by Atomic Energy of Canada Limited; significant technological advances in Canadian farming have occurred as the results of efforts by the Department of Agriculture; the industrial exploitation of visual and interactive displays of computer-based information is currently being fostered by the Department of Communications, and the Department of Energy, Mines and Resources has made a major contribution to the technology of open-pit mining by developing a pit-slope manual in cooperation with industry. Another major contribution by the Department of Energy, Mines and Resources was the heavy oil technology development made possible by the transfer of the department's hydrocracking process to Petro-Canada Explorations, Inc., for commercialization. An explicit and successful program of technology transfer is the above-mentioned Program for Industry/Laboratory Projects (PILP), established by the National Research Council in 1975 and now administered by that organization on behalf of all federal departments and agencies.

Scientific and technical information services are another means for encouraging the application of new technology in Canadian industry. Within the National Research Council's Scientific and Industrial Research Program, the Canada-wide Technical Information Service has as an objective the fulfillment of the technical information needs of industry, particularly small business, which often operates without an internal R & D capability. Annually the service receives 20,000 to 25,000 enquiries and provides in-depth assistance to 500 to 700 firms. Additional details about the Technical Information Service are given in the Major Participants (NRC) section. Complementary specialized technical information services are provided by other departments in connection with their R & D activities.

University

The federal government supports university science and technology both directly and indirectly through transfer payments to the provinces. Direct support takes the form of (a) grants and contributions and (b) contracts for S & T work in support of departmental missions. Total expenditures in direct support of university S & T in 1982/83 are estimated to be $441.2 million, a 13% increase from those of 1981/82 and 38% from those in 1980/81. Further details are given in Table 4.4.

The greater portion, 89%, of direct payments to universities supports R & D activities; the remainder is for RSA. Most of the direct support is channelled through R & D grants ($347.3 million for 1982/83). The amount spent by the government on R & D contracts in the university sector is expected to be $27.1 million in 1982/83, compared to $23.4 million in 1981/82. Of the expenditures on RSA, 76% ($36.9 million) falls within the "education support" RSA category, which covers grants to individuals or institutions intended to support the post-secondary education of students in the natural and engineering sciences ("General purpose" grants to institutions are not regarded as scientific expenditures).

The three granting councils—The Medical Research Council, the Natural Sciences and Engineering Research Council, and the Social Sciences and Humanities Research Council—provide about 82% of the total direct federal payments to universities for scientific activities. The remainder is provided by other departments and agencies, which also provide approximately half of the indirect costs of these activities through Established Program transfers to the provinces for post-secondary education and hospital and medical care.

The federal government considers the strengthening of the university research capability to be a national responsibility. The support of university research is aimed at the development and maintenance of our national capacity for fundamental research, at having part of that capacity address problems of national concern, and at underpinning the training of the manpower needed to carry out future research. During 1981/82 the budgets of the three granting councils were significantly increased, allowing the councils to enhance existing programs and to develop their new programs instituted to meet national needs.

As provided for in the 1982/83 Main Estimates, university payments by the Medical Research Council are estimated to be $107.1 million, an increase of 12.7% over 1981/82 and 38.2% from 1980/81. Most of the additional funds were devoted to increasing the support provided for existing programs, although two significant shifts in program development are now evident.

First, biological engineering has been identified as a field requiring additional research. Support for work in this field holds the promise of new diagnostic and therapeutic processes and industrial benefit from them. However, Canada has limited capabilities and there-

Table 4.4

Federal Science Expenditures in Universities

	1980/81	1981/82	1982/83
		(millions of dollars)	
Total Payments to Universities	**320.0**	**390.4**	**441.2**
R&D Grants and Contracts (Total)	**284.6**	**347.3**	**393.6**
Natural Sciences (Total)	**254.1**	**312.6**	**351.2**
R&D Grants (Total)	232.9	281.7	314.4
Medical Research Council	72.2	88.1	99.3
Natural Sciences and Engineering Research Council	136.8	164.8	182.5
National Research Council	13.5	17.1	21.2
Others	10.4	11.7	11.4
R&D Contracts (Total)	16.1	21.6	24.9
Research Fellowships (Total)	5.1	9.3	11.9
Human Sciences (Total)	**30.5**	**34.7**	**42.4**
R&D Grants (Total)	22.8	26.3	32.9
Social Sciences and Humanities Research Council	18.2	19.7	26.1
National Health and Welfare	3.1	3.5	3.4
Others	1.5	3.1	3.4
R&D Contracts (Total)	1.7	1.8	2.2
Research Fellowships (Total)	6.0	6.6	7.3
RSA Grants and Contracts (Total)	**35.4**	**43.1**	**47.6**
Natural Sciences (Total)	**19.9**	**25.4**	**28.3**
Education Support (Total)	16.2	20.9	23.4
Medical Research Council	2.0	2.7	3.0
Natural Sciences and Engineering Research Council	13.4	17.5	19.5
Others	0.8	0.7	0.9
Other RSA (Total)	3.7	4.5	4.9
Human Sciences (Total)	**15.5**	**17.7**	**19.3**
Education Support (Total)	11.0	12.4	13.5
Social Sciences and Humanities Research Council	7.1	8.0	8.9
Others	3.9	4.4	4.6
Other RSA (Total)	4.5	5.3	5.8

fore needs additional manpower trained in this area. Accordingly, the council has decided to include the field of biological engineering among those in which some degree of preference is given to candidates for MRC fellowships.

A second development in the funding of medical research has been the awarding of funds under the Subject Research Development program to support research in perinatology. Originally designated by the council as an area of national concern in 1979, perinatology follows heart research as a topic to be singled out by this program. The intention of the council is to create leading centres of research in perinatology, which will give particular attention to work on the causes and the management of pre-term birth and the problem of neonatal asphyxia.

The Natural Sciences and Engineering Research Council estimates that payments to universities will be $209.5 million, an increase of 11.6% over the 1981/82 level and 37.6% over the 1980/81 level. Implementation of the policies and programs contained in the Council's five-year plan began in 1980/81. Various committees and task forces worked to establish priorities and allocate additional funds both to existing programs and to new initiatives. As a result of extensive consultation, two new university support initiatives were implemented, designed to improve the supply of research trained manpower: these were the program of Research Fellowships and the program of Undergraduate Summer Research Awards. The third new initiative was an expansion of the existing Strategic Grants program, through the addition of a new area of interest.

The Undergraduate Summer Research Awards program is intended to encourage undergraduate students in science and engineering to gain experience in research. During the summer of 1981 over 2,000 awards were offered to undergraduates to work as research assistants at the university. The Research Fellowship program is aimed at developing and maintaining a strong base of excellent research within the university community and retaining some of the involved researchers as the nucleus of a group of young Canadian professors which will be required in the 1990s. In the first year of this program about 100 research fellowships were awarded to researchers holding both a doctorate and other qualifications of the kind usually required for applicants to Assistant Professor positions. This program has been expanded through the addition of a program of fellowships tenable in industry.

The third new initiative was the council's invitation to a limited number of applicants to submit research proposals in fields of national concern that lie outside the five areas specifically selected for support under the council's Strategic Grants Program.

In addition to these new initiatives, the council approved funding increases to improve the quality of the university research supported by its existing programs. Such increased funding will allow the council to stimulate further the training of highly qualified manpower through an expanded postgraduate scholarships program, to increase support for "targeted" research in areas of national concern, to improve most of the scientific equipment which has become obsolete over the past decade, and to improve linkages between university and industrial research. In line with the recommendations of the council's five-year plan, the largest 1981/82 budget increases related to equipment replacement and improvement, targeted research and the training of scientific manpower.

The Social Sciences and Humanities Research Council in its areas of influence will provide an estimated $45.2 million in 1982/83 for university S & T activities in the humanities and social sciences, compared with $36.6 million in 1981/82. The council's five-year plan, which it presented to government in 1979, proposed four main program thrusts for the 1980s:

- to maintain and expand core activity for support of independent research;
- to substantially expand support of research on subjects of national importance;
- to improve the dissemination of the results of research and scholarship;
- to enhance the quality and extent of basic research facilities and instruments.

The fellowship and scholarship programs, administered by the Fellowships Division, constitute the largest expenditure category in the council's budget: 41% in 1981/82 for the support of over 1,800 students and scholars. These programs include Special MA Scholarships, The Queen's Fellowships, Doctoral Fellowships, Leave and Postdoctoral Fellowships, and Doctoral Completion Fellowships for university faculty in management and administrative studies.

The Research Grants program supports advanced research in the social sciences and humanities. Grants in 1980/81 totalled some $8 million for 561 new and ongoing projects. Fields of research covered a broad range, from social history to the economic analysis of Canadian industry and resources and including Canadian literature; arts, philosophy, the psychological development of the child, and urban and regional studies. Here are some representative projects: a study on the adoption of bilingual programs in Canada, publication of the results of research into the evolution of poetry in Atlantic Canada between 1749 and 1867, a study on the measure of economic growth, support of archeological research at the Iroquois Draper site north of Toronto.

Following an evaluation of its programs, the council has integrated its Strategic Grants program within its Research Grants Division. Notwithstanding this change, the council continues to support large-scale research and publication projects, usually of university groups, extending over several years. In 1980-1981, $8.3 million were allocated to new and ongoing projects under the Program Grants and the Major Editorial Projects Grants program. Twenty-five projects received grants; 15 were in research areas and 10 were editorial. Examples include a project on ocean law, policy and management, a research study on juvenile maladjustment. The Historical Atlas of Canada/l'Atlas historique du Canada, contributed to by researchers from 28 universities and other Canadian institutions is an example of a 1980/81 Editorial Project.

The Strategic Grants program, which provides support for research in areas of national concern and for research resources, funded projects to a value of some $1.9 million in 1980/81. This program has made great strides following study and national consultation on research needs. Three new research areas have been identified. These are the family and socialisation of children, human context of science and technology, both within the thematic programs; and finally research tools in the Canadian Studies fields, as a program in a special fields.

Studies in these new areas are being supported in addition to the work already funded by the Council. In the field of population aging, Special Research Grants were given for 20 projects on subjects such as differential aging and the psychosocial environment, the old and the community and loneliness among the old in the rural environment. Reorientation Grants were awarded to universities wishing to redirect their interests into the field of population aging, and Postdoctoral Fellowships were given for research in aging involving the disciplines of sociology and psychology. In addition, some research workshops were funded and some institutions assisted to invite researchers from abroad.

Complementing the Medical Research Council's support of university science in the health field is the National Health Research and Development Program of the Department of National Health and Welfare. This program accounts for about 80% of the department's payments for university health science estimated to be $11.3 million in 1982/83. Since 1975, the program has been influential in expanding and upgrading research in the health care field, including social, community and preventive medicine, dentistry, nursing, occupational health, health care administration and allied areas related to public health. The program will continue its support of those areas in future years and will make special attempts to encourage proposals for scientific study of high priority issues such as aging and health, problems of the disabled, health promotion, and the availability, accessibility and quality of health care. Complementing the Social Sciences and Humanities Research Council in the social welfare field is the Department's program of National Welfare Grants. It has been influential in expanding and upgrading applied research in the field of social work, through the development of university research and research training capability and the provision of fellowships to students undertaking such training.

Through the National Research Council the government will provide $20.9 million in 1982/83 for its continuing contribution for ancillary equipment and operating costs at TRIUMF, the medium energy proton accelerator and meson facility located at the University of British Columbia. Research projects using TRIUMF are funded through the Natural Sciences and Engineering Research Council and other non-federal sources. The Department of Energy, Mines and Resources through its Research Agreements program and other grants and contributions and contracts supports R & D in Canadian research organizations outside the federal government including universities. The estimated payments to universities for 1982/83 are $4.9 million, $3.0 million in contracts and $1.9 million in grants and contributions. Over 90% of the grants are awarded to Canadian universities, and the balance to provincial research organizations, industry and to non-profit organizations. These arrangements provide an important link between the department and the Canadian research community, ensuring the free flow of information, expertise and technology. It gives the non-federal government research community an opportunity to contribute its expertise to the achievement of national objectives through mission-oriented R & D.

Like other federal science departments, the department is concerned about the future supply of highly qualified manpower in those areas of science and engineering within its mandate. Through the Research Agreement program, graduate students working with the department's grantees can apply their newly gained knowledge to solving real problems. Roughly 65% of the grant funds awarded each year assist in developing this highly qualified manpower through the employment of graduate students. The Department also funds R & D activities in Canadian universities through the awarding of contracts for specified R & D. It is estimated that in 1982/83 contracts amounting to approximately $2 million will be awarded to Canadian universities.

Support of university research by the Department of Agriculture in 1982/83 is estimated at $5.6 million, of which $1.3 million will be in operating grants, and $4.2 million in contracts for research directly complementing departmental activities. The Department of the Environment will provide $4.2 million in 1982/83 for university S & T in such areas as forestry, water and the atmosphere. The Canadian Forestry Service provides a total of $292,000 annually to the six forestry schools, and it also spends about $760,000 annually for contract research in the universities, mostly through the ENFOR program. The Canadian Forestry Service also helps universities by making available staff and facilities from time to time for teaching purposes. Research contracts and grants to universities by the Department of National Defence are expected to amount to $5.1 million in 1982/83, compared to $4.3 million in 1981/82. In addition, almost $0.5 million will be awarded through grants to universities to endow professorships in strategic studies.

Transport Canada will continue its support of university research and research training in disciplines and areas of study of relevance to the transportation field. The 1982/83 expenditures under the Transport University

Programs (Fellowship, Negotiated Research Contributions and Centre Support Grant Programs) are estimated at $1.1 million, an increase of 10.3% from 1981/82.

The University Research program in the Department of Communications has been supporting applied research in Canadian universities since 1971. Estimated funds for 1982/83 are $1.0 million. The objectives are to complement the departmental research activities and to develop a cadre of competent university researchers upon whom the department can call on for assistance. The areas of research are defined by a University Research Advisory Board, in response to requirements expressed by the department. The main criterion in assessing contract proposals and awarding contracts is the probable impact in meeting departmental objectives. The program reaches all Canadian universities and contributes to the development of expertise in both the socio-economic and technological aspects of telecommunications.

Provinces

Federal-provincial interaction in science and technology arises in three ways: the federal government makes direct payments to provinces for various S & T activities; there are joint federal-provincial S & T programs and the federal government undertakes S & T activities in which the provinces have an interest. There are numerous federal-provincial coordinating committees concerned with special science areas. For example, the Canadian Agricultural Research Council meets regularly to coordinate agricultural research in Canada. The Coordinating Council of Resource and Environment Ministers deals with environmental matters which include S & T as a major component. On a bilateral basis, there is for example, the Canada-Ontario Forestry Research Advisory Council.

Departmental payments to provincial governments either directly or through joint programs are shown in Table 4.5. The Department of Energy, Mines and Resources is the largest spender, with estimated expenditures in 1982/83 of $56.9 million on joint programs with the provinces. Payments to the Alberta/Canada Energy Resources Research Fund ended in 1981/82 with the payment of $24.0 million. This fund has been used for energy research and development projects, such as the Coal Mining Research Centre at Devon, Alberta, which is conducting research primarily in the areas of coal mining and coal beneficiation. Under Special Atlantic Initiatives of the National Energy Plan, $1.25 million will be spent in the Maritimes in 1982/83 for R & D related to coal; a further $11.1 million will be available for R & D, demonstration and commercialization of advanced coal utilization technologies, including the fluidized bed furnaces at Summerside, P.E.I. About $5 million will be contributed by the government in 1982/83 to the joint Canada-Saskatchewan program for the development of heavy oil recovery technology. The federal share of federal-provincial agreements to demonstrate conservation and renewable energy technologies is estimated to be $33.5 million in 1982/83, compared to $12.0 million in 1981/82.

Table 4.5

Federal Science Expenditures in the Provincial Sector

	1980/81	1981/82	1982/83
		(millions of dollars)	
Total	**46.6**	**62.7**	**80.0**
Energy, Mines and Resources	29.8	46.0	56.9
Environment	4.3	4.8	5.1
National Health and Welfare	2.0	2.4	2.4
Regional Economic Expansion	1.0	1.2	5.8
National Museums	5.9	6.1	6.6
Others	3.6	2.2	3.2

The Department of the Environment will spend about $5.1 million in 1982/83 on joint ventures with the provinces. The provincial S & T payments by the National Museums of Canada—an estimated $6.6 million in 1982/83—provide support for regional and provincial museums and fall entirely within the related scientific activity, museum services. The Department of Regional Economic Expansion will spend about $5.8 million in 1982/83 in support of S & T including programs of research on the development and adjustment of manpower resources in selected areas and for development services to industry. Most of the S & T activities funded by the department are in the provinces of Newfoundland, Nova Scotia and Quebec.

Included the 1982/83 payments of $2.4 million to the provinces by the Department of National Health and Welfare will be contributions, through the Canada Assistance Plan, to support the development of research activities and related infrastructures of provincial departments of welfare. The department also gives technical and financial assistance to the provinces to develop effective social services information systems.

Foreign

With respect to the federal S & T expenditures in foreign countries shown in Table 4.6, those of the International Development Research Centre and the Canadian International Development Agency far outweigh the others. For these two agencies the use of foreign performers follows naturally from their mandate to aid developing countries with tangible material assistance (the Canadian International Development Agency) and with assistance in establishing the means of self-development, which is a hallmark of the International Development Research Centre's operations. Other departments and agencies may use foreign performers when the needed research capabilities or training are not available in Canada. Also included in the category of "foreign" expenditures are the dues paid for affiliation with international scientific organizations, and the costs of participation in international science projects.

For example, among the foreign expenditures of the National Research Council are:

- $1.7 million for support of the Canada-France-Hawaii telescope;
- $0.3 million for support of several energy projects under the aegis of the International Energy Agency, and
- membership dues in such organizations as the International Council of Scientific Unions, the International Union of Pure and Applied Chemistry, the International Bureau of Weights and Measures.

Foreign expenditures by the Ministry of State for Science and Technology provide:

Table 4.6

Federal Science Expenditures in the Foreign Sector

	1980/81	1981/82	1982/83
		(millions of dollars)	
Total	**57.5**	**67.5**	**75.1**
Communications	1.6	3.3	—
Social Sciences and Humanities Research Council	2.6	3.1	3.5
Energy, Mines and Resources	1.4	1.3	3.0
Canadian International Development Agency	9.6	10.8	12.3
International Development Research Centre	26.7	30.4	36.5
National Defence	2.8	2.0	2.6
Medical Research Council	2.8	3.2	3.6
Science and Technology	1.9	2.0	2.4
National Research Council	2.0	2.2	2.7
Natural Sciences and Engineering Research Council	3.2	3.9	4.3
Others	2.9	5.3	4.2

- $0.5 million for Canada's contribution in 1982/83 to the activities of the International Institute for Applied Systems Analysis, of which Canada was a founding member, and
- $1.9 million in 1982/83 towards the fixed costs and general studies budget of the European Space Agency under the terms of Canada's cooperative agreement with the agency.

Under the terms of this agreement, Canada is already participating in two projects, in the development of the European ERS-1 (a remote sensing satellite) and the development of LSAT, an experimental communications satellite. This will provide Canada a share of the first satellite and a guaranteed share in future commercial versions. It is expected that Parliamentary approval will be sought for Canada's continued participation in the development of the LSAT satellite.

Apart from its contribution of $0.9 million to ERS-1 in 1982/83, the Department of Energy Mines and Resources also contributes $0.25 million per year to obtain data from the LANDSAT operated by the U.S. National Aeronautic and Space Agency.

Foreign expenditures by the Department of National Defence are for contracts for scientific activities that cannot be undertaken in Canada. These contracts are with government agencies and companies in the United States, Great Britain and other countries, which have unique capabilities in such areas as electronics, avionics and communications.

The Social Sciences and Humanities Research Council incurs foreign expenditures in supporting Canadian post-graduate students working towards doctoral degrees. The Medical Research Council's foreign expenditures include both fellowship awards and grants to Canadian scientists visiting outside Canada. In addition to expenditures for these kinds of support, the National Sciences and Engineering Research Council also contributes under an international exchange program to the cost of bringing foreign scientists to work for a time in Canada and of sending Canadian scientists abroad.

5. Major Participants

Introduction

The government's expenditures on science activities in some broad areas of national concern are discussed in the Major Applications section. In contrast, this section focuses on the science activities and budgets of individual departments or agencies, describes their science objectives and the organization of their science activities. The order in which departments are described in this section corresponds to the order of presentation within the Main Estimates, that is, by portfolio, by department or agency and by Budgetary Program.

A summary of expenditures in millions of dollars for S & T in the Natural and Human Sciences and for R & D in the Natural Sciences for the past, current and "estimates" fiscal year is presented for each department and agency discussed, as well as figures for the total Program resources provided for activities of all kinds. A display of the science expenditures and personnel resources linked with corresponding Parliamentary Vote numbers is given in Appendix II. Additional detailed data are to be found in the companion document "Federal Science Expenditures and Personnel, 1982/83".

In most departments and agencies only a portion of a departmental budget is allocated to science activities, and this can vary from year to year depending on the extent to which the departmental managers use science as a means to achieve their objectives. Within some departments science activities are sometimes concentrated in one particular branch, such as the Research Branch within the Department of Agriculture's Agri-Food Development Program. Even in such departments, other parts of its organization may also conduct scientific activities; for example within the department's Agri-Food Regulation and Inspection Program, the Health of Animals Directorate conducts research on diseases causing livestock losses.

It is not feasible to present all departmental scientific and technological endeavours in detail; for several departments much of their S & T activity has already been discussed in the Major Applications and Extramural Science Expenditures sections. Examples of activity highights or details of important activities not presented elsewhere in the report are given in this section.

Department of Agriculture

Program	Science Resources						Total Resources
	1980/81		1981/82		1982/83		1982/83
	S&T*	R&D*	S&T	R&D	S&T	R&D	
	(millions of dollars)						
Administration	4.2	—	4.8	—	5.1	—	44.2
Agri-Food Development	140.7	136.9	155.1	151.7	178.8	176.1	687.6
Agri-Food Regulation and Inspection	4.6	4.6	5.1	5.1	8.0	8.0	185.5
Canadian Grain Commission	2.9	1.4	3.5	1.7	4.2	1.9	35.7
Total	**152.4**	**142.9**	**168.5**	**158.4**	**196.1**	**186.0**	**953.0**

[*] In this and subsequent tables in this section, S&T refers to the sum of R&D and RSA (Related Scientific Activities) in both the Natural and Human Sciences. R&D refers to R&D in the Natural Sciences only.

The objective of the Department of Agriculture is to contribute to the development of optimum agricultural and food production and to ensure the continual supply of safe, wholesome, high quality and nutritious food for domestic and export trade. The estimated S & T expenditures in 1982/83 for the department are $196.1 million, an increase of $27.6 million or 16.4% over 1981/82. Approximately 6% of the S & T activities are performed extramurally.

The major portion of the department's science activities is conducted by the Research Branch within the Agri-Food Development Program. The Research Branch is organized into five regions reflecting the department's regional concerns. The purpose is to solve the problems identified at the 52 regional responsibility centres located from coast to coast, by working in closer contact with the provincial departments of agriculture, the agricultural industry, and the various farm organizations across the country.

The Research Branch conducts basic and applied research on agricultural problems pertaining to soils, farm animals, plants and pests that occur in the widely differing soil and climatic zones of Canada. Focal topics for scientific work include diseases, insects and weeds, engineering and energy resources, and food.

The branch has increased its emphasis on fundamental research in biotechnology and engineering which will lead to the breakthroughs needed for increased efficiency in both crop and animal production. The ultimate aim of such research is to increase the production of food, to improve the safety and nutritional quality of food, and to build a profitable food industry. The program also includes economic and social research concerned with the agriculture/food system.

Research on animal diseases is carried out within the Agri-Food Regulation and Inspection Program. Such research covers new or emergent animal diseases and meat safety; food additives, residues, bacteriology, and food-bore diseases.

The scientific activities reported under the Administration Program involve the operation of the department's Central Library.

The Grain Research Laboratory of the Canadian Grain Commission conducts research on the quality of grain and oilseed crops.

Department of Communications

	Science Resources						Total Resources
	1980/81		1981/82		1982/83		1982/83
Program	S&T	R&D	S&T	R&D	S&T	R&D	
	(millions of dollars)						
Communications	65.3	60.5	81.3	76.1	66.7	61.3	158.5
Arts and Culture	0.7	—	1.0	—	0.8	—	237.8
Total	**66.0**	**60.5**	**82.3**	**76.1**	**67.5**	**61.3**	**396.3**

The department now has two budgetary programs. Responsibility for the Arts and Culture Program, formerly in the Department of the Secretary of State, was transferred to the Department of Communications in 1980.

The department's estimated science expenditures for 1982/83 are $67.5 million, compared to 1981/82 forecast expenditures of $82.3 million. These expenditures represent 17% of the total estimates for the department. $11.2 million will be spent extramurally, with 91% going to industry and the remainder to universities. It is to be noted that a significant fraction of the department's S & T activities is characterized by large satellite development projects, which results in marked variations in the annual expenditure trend.

The bulk of the department's S & T activities under the Communications Program is conducted within Telecommunications Research and Space Applications activities. Scientific activities are also to be found in the National Telecommunications Development, Management of the Radio Frequency Spectrum and International Participation activities.

Most of the department's intramural research is conducted at the Communication Research Centre, located to the west of Ottawa. The centre is divided into two sections, one for Space Technology and Applications and the other for Radar and Communications Technology Research and Development. Under an agreement with the Department of National Defence, the department also conducts basic and applied research in radar and radio phenomena on behalf of the Canadian Armed Forces. Aspects of this work have included the development of airborne radar and remote sensing systems, and research into military communications systems. Among other activities, the Space Technology and Application section manages the David Florida Laboratory, which has recently underdone a large expansion in order that it may carry out tests and provide support for Canadian space activities in industry, universities and other government departments. The laboratory provides specialized test equipment for satellites including thermal vacuum and vibration testing facilities. Additional information about the department's activities may be found in the Major Applications sections on Space and on Communications.

The National Library of Canada

	Science Resources					
	1980/81		1981/82		1982/83	
Program	S&T	R&D	S&T	R&D	S&T	R&D
	(millions of dollars)					
Program Expenditures	17.2	—	21.6	—	25.8	—

The total budget of the National Library constitutes "related scientific activities" in the provision of information services in the human sciences. This activity is performed intramurally. The estimated expenditures for 1982/83 are $25.8 million, an increase of $4.2 million or 19.4% from the previous year.

To carry out its functions, the National Library's program is organized into five activities: Administration, Library Systems Centre, Collections Development, Cataloguing and Public Services.

As a national institution, the National Library has a responsibility to collect and to promote Canada's printed heritage, and to ensure the proper listing of the nation's publications to facilitate their retrieval, availability and use. It also facilitates the use of the nation's total library resources through the maintenance of union catalogues and the publication of union lists of periodicals held in Canadian libraries. Lending and research activities are also supported by the development of a broad collection of books, periodicals and government documents in the fields of the social sciences and humanities.

The National Library assists other libraries in the cataloguing and classification of their own collections by providing them with both current and retrospective bibliographic information in a variety of formats. Catalogue data for Canadian publications is created and provided by the Library itself, and data for foreign publications is obtained and provided through the international exchange of machine-readable records.

The National Library's automated on-line library data base management system, DOBIS, is operated not only as a shared system for federal libraries but also as the Canadian Government node in the developing decentralized nation-wide library and information network. At present, the DOBIS data base contains over

2.5 million records describing books and periodicals, and the system is being used by the National Library, the Canada Institute for Scientific and Technical Information (CISTI), the Library of Parliament and a number of departmental libraries including Finance/Treasury Board, Public Service Commission, Transport Canada and the Atomic Energy Control Board.

In a network mode, the National Library is testing, with DOBIS and other systems, the feasibility of bibliographic interchange in the Open Systems Interconnection (OSI) environment, through participation in the Computer Communications Group's i-Net Gateway trial.

National Museums of Canada

	Science Resources					
	1980/81		1981/82		1982/83	
Program	S&T	R&D	S&T	R&D	S&T	R&D
	(millions of dollars)					
Program Expenditures	54.0	1.1	58.7	2.2	61.8	1.3

The National Museums of Canada is another of the federal government agencies and departments whose science budget constitutes 100% of the total program. Museum services are classed as a related scientific activity. The agency estimates total expenditures of $61.8 million for 1982/83. Approximately 18% is spent extramurally, in the form of grants to other museums and other organizations in Canada for their operations, special projects, purchase of equipment and construction of facilities.

The agency's objectives include the acquiring, classifying, preserving and exhibiting of both natural and man-made objects of cultural and scientific importance in an attractive and interesting way so as to stimulate, educate and inform the Canadian public. To achieve these objectives the agency's program is organized into four activities, corresponding to the following fields: fine arts, including Canadian and non-Canadian sculpture, paintings, and the like; natural sciences, including botany, zoology, paleontology and mineral sciences; human history, including archeology, ethnology, folk culture, and Canadian history; and science and technology, including industry and the physical sciences. A fifth activity, National Programs, is the mechanism through which the agency cooperates with other museums in preserving collections, making inter-museum loans, and extending museum services directly to the public in areas not otherwise served.

Research plays an important role in the program of the National Museums of Canada. Research and interpretation of data are carried out on all the museums' collections of natural objects, man-made artifacts and works of art, including their nature, provenance and preservation, and the knowledge gained is disseminated through displays and by publication.

Social Sciences and Humanities Research Council

	Science Resources					
	1980/81		1981/82		1982/83	
Program	S&T	R&D**	S&T	R&D	S&T	R&D
	(millions of dollars)					
Grants and Scholarships	38.4*	—	42.2	—	51.3	—
Administration	4.0	—	4.5	—	5.3	—
Total	**42.4**	**—**	**46.6**	**—**	**56.7**	**—**

* Includes transfer from other departments ($0.7 million).

** R&D refers to R&D in the Natural Sciences only.

All of the expenditures of the Social Sciences and Humanities Research Council are devoted to S & T activities. The expenditures for 1982/83 contained in the Main Estimates are $56.7 million, an increase of $10.1 over the amount forecast for 1981/82, an increase of 21.7%. Expenditures for administration go toward maintaining infrastructure to support the council's relations with a large and heterogeneous scholarly community numbering some 18,000.

The objective of the council is to promote and assist research and scholarship in the social sciences and humanities. The council:

- supports such independent research as in the judgement of scholars will best advance knowledge;
- encourages research on subjects considered by the council to be of national importance;
- facilitates the dissemination and exchange of the results of research and scholarship, within Canada and externally;
- assists in and advises on maintaining and developing the national capacity for research.

In addition to its programs of grants and fellowships, which are discussed in the Extramural-University section, the council also provides assistance to the scholarly community through a series of consultative groups, composed of specialists in various fields. These groups which study and report on the research needs of selected disciplines and make recommendations to the Council. Two consultative groups were at work in 1980/81; one on research and education in law and the other on research in education.

The scholarship and fellowship programs, administered by the Fellowships Division, represent the largest share of council expenditures—over 38% in 1980/81.

Within its Research Grants program the council's first priority is the support of independent research. Grants in 1980/81 totalled over $8 million for 561 new and ongoing projects. General Research Grants to 75 universities to cover the costs of certain research requirements of their faculty totalled $2.7 million.

Strategic grants under the council's program of assistance to thematic research in areas of national concern, amounted to $0.6 million in selected fields. For example, within the population aging theme, assistance included research grants, postdoctoral and reorientation fellowships, research workshops and institutional assistance. Special grants were also made to university libraries for the strengthening of specialized collections. Support was also given for development of research in management, seminars on research methods and research colloquia.

The Negotiated Grants Program now integrated within the Research Grants Division supports large-scale research and editorial projects undertaken by eligible institutions—usually universities or university presses—by groups of scholars over a period of years. Two types of awards are available: Program Grants and Major Editorial Grants. Payments for such projects totalled $8.3 million in 1980/81. The Research Communication Division subsidizes learned journals in the social sciences and humanities, publication of scholarly manuscripts, and travel to scholarly conferences in Canada. In 1980/81, grants of some $1.5 million were awarded to 112 learned journals; grants totalling some $0.4 million were made to suport 124 conferences and seminars.

Support for Canadian learned societies comprises assistance (totalling $1.6M in 1980/81) in connection with the annual meetings of these societies and necessary administrative support. A portion of this assistance is provided through block grants to the Social Science Federation of Canada and the Canadian Federation for the Humanities. Grants are also provided to these organizations for the publication of scholarly manuscripts ($1.0M in 1980/81).

The council's Office of International Relations provides grants to enable scholars to participate in scholarly exchanges at important meetings held outside Canada, and for scholars who hold high executive office or key ad hoc positions in international scholarly organizations, to travel to management and policy meetings. Grants for international collaborative research are for a) small seminars, workshops or colloquia organized jointly by Canadian and foreign scholars to plan, coordinate or evaluate cooperation on specific research topics, and b) consultations between Canadian and foreign scholars on joint or parallel research projects.

The council promotes and administers international scholarly exchanges through special exchange programs. It has concluded international agreements for exchanges of scholars with research institutes and academies in France, Japan, the Soviet Union, and Hungary and China.

Department of Energy, Mines and Resources

	Science Resources						Total Resources
	1980/81		1981/82		1982/83		1982/83
Program	S&T	R&D	S&T	R&D	S&T	R&D	
			(millions of dollars)				
Administration	—	—	—	—	—	—	23.3
Energy	48.5*	45.8	70.3*	65.8	81.6	75.2	3,809.2***
Minerals and Earth Science	130.5**	82.6	159.4**	106.6	198.9**	136.5	222.6
Total	**179.1**	**128.4**	**229.7**	**172.4**	**280.5**	**211.7**	**4,055.1**

* Excludes transfers to other departments ($18.1 million in 1981/82).
** Includes net of transfers to and from other departments ($0.7 million in 1982/83).
*** Includes Oil Import Compensation Payments ($2,983.2 million in 1982/83).

The department's total estimated expenditures for scientific activities in 1982/83 are $280.5 million, an increase of $50.8 million or 22% over 1981/82, reflecting major increases for energy R & D and demonstrations in the National Energy Plan. These S & T expenditures will be 7.6% of total departmental expenditures, exclusive of expenditures for oil import compensation. Extramural expenditures are estimated to be $106.2 million, $36.7 million to industry, $4.9 million to universities and $56.9 million to provincial governments. The payments to industry represent an increase of 17.8% from 1981/82, those to provinces an increase of 23.6%.

The department's two main areas of responsibility are to stimulate the discovery, development, use and conservation of Canadian mineral and energy resources, and to provide the earth science information needed for effective use and demarcation of the country's land mass. The accomplishment of these tasks necessitates ongoing research and information-gathering in the fields of geology, surveys and mapping, earth physics, remote sensing, energy, and resource technology, as well as in mineral and energy economics and statistics, the results of which form the basis for planning and policy formulation in resource development. The relevant information is also made available to the private sector through departmental information units, joint industry-government programs, and the contracting-out of studies and projects.

The objective of the department's Energy Program is to ensure the availability and to promote the effective use of energy resources for Canada, with due regard for other social and economic goals. The principal departmental groups concerned with energy S & T are the Canada Centre for Mineral and Energy Technology, which conducts energy research in its laboratories and pilot plants; the Geological Survey of Canada, involved in studies of oil, gas and uranium resources; the Earth Physics Branch, studying geothermal potential, and the Office of Energy Research and Development, which provides coordination and facilitates improved management of the government's total energy R & D program. The Conservation and Renewable Energy Branch has been consolidated with the Electrical, Coal, Uranium and Nuclear Group to facilitate policy coordination among the non-petroleum energy options.

Energy R & D at the Canada Centre for Mineral and Energy Technology is focussed primarily on fossil fuels such as oil sands and coals, in which the centre has exercised technological leadership for many years. Substitution for oil, efficiency of use, and development of low-grade resources are stressed. Demonstration projects with the centre's participation, complemented by in-house and contract research, are underway or contemplated in such areas as fluidized-bed technology, coal-oil mixture combustion and heavy-oil upgrading.

Further discussion of the department's energy activities is to be found in the Major Applications-Energy section. In addition to those activities coming under the coordination of the Panel on Energy R & D, the department also conducts environmental and socioeconomic impact assessments of resource exploration, development, production and transportation both on land and in offshore regions.

The objective of the Minerals and Earth Sciences Program is to ensure the availability of mineral policies and strategies and timely earth science information, technology and expertise related to the landmass of Canada and its mineral and energy resources. Because of its important place in the economy, the mineral industry has a number of economic, social and policy implications, and research in the social sciences plays a significant role in dealing with these, particularly in the areas of international trade, frontier development, and employment opportunities. Analysis and evaluation of the impact of changing patterns of mineral activities are required to develop strategies for ensuring maximum benefits from resource utilization. The mineral research program includes resource determination and technology development. Mining studies focus on mine design and health and safety. Research on mineral processing emphasizes improving established processes for better environmental control, and developing new techniques to use low-grade and complex ores and waste materials. Mineral-based materials are studied to improve their fabrication methods and serviceability. Estimates of mineral resources and the improvement of methods of resource estimation are provided by the Geological Survey of Canada.

The Geological Survey of Canada is concerned with the provision of geological information on the earth's surficial deposits, crust and upper mantle. This is needed for the identification of the resource base of Canada and the effective exploration of the mineral and energy resources. It provides by means of geoscientific surveys and research an increasingly comprehensive knowledge of the geology of Canada, including its surrounding off-shore areas. The knowledge base is disseminated mainly as geological, geophysical and geochemical maps, reports and open files. The information and knowledge gained from the study of mineral deposits is being used more and more to provide evaluations of the mineral resource base of specific areas, such as proposed national parks. Some of the airborne geophysical and the geochemical surveys are undertaken as shared-cost federal-provincial ventures.

In addition to its energy R & D program, the Canada Centre for Mineral and Energy Technology (CANMET) also conducts S & T activities with the objective of ensuring that Canadian industry has the technology needed to meet national mineral and energy goals and to maintain a competitive position in world market. The centre's research program and information and advisory services extend from resource assessment to end use for a variety of mineral commodities. In its mineral technology work, the centre stresses problems and opportunities that are peculiar to the Canadian scene. Major projects are underway on mining methods for Canadian orebodies and processing of low-grade indigenous resources of long-term interest. Scientists are addressing the critical economic importance of durability, wear and corrosion in the Canadian climate and of the needs of the transportation industry, through research on improved mineral-based materials. Projects are designed to maximize the efficiency of materials and energy utilization while keeping environmental pollution and health and safety hazards at a minimum.

Cooperation and collaboration with private industry is a tradition at the centre. Through contracts, joint projects and a sophisticated information transfer system, the centre works to ensure that industrial needs are met and that technical capability is available for prudent and efficient resource development in Canada.

The Earth Physics Branch conducts a comprehensive program in solid earth geophysics. Ongoing activities include the determination of seismicity and seismic risk in all parts of Canada, delineation of the geomagnetic field of the earth and its variations and anomalies, delineation of the gravity field of the earth including anomalies, delineation of the geothermal regime including prediction of permafrost and studies of deep crustal structure and control. A revised seismic risk map is produced at ten-year intervals and site-specific determinations are made for industry on request. New techniques include the use of satellite data in magnetic and geodynamic studies. These activities support policy-making bodies, regulatory agencies and industry in such areas as navigation, transportation, communications, surveying and geophysical prospecting, and provide data and information for research and development by government and other sectors. The Earth Physics Branch is the lead agency in the government for research into sources of geothermal energy in Canada and is Program Manager for geophysical research into the problem of underground storage and disposal of radioactive waste from reactors. The Branch is presently engaged in planning CESAR '82, a program of geophysical exploration over the Alpha Ridge in the Arctic Ocean. Interdisciplinary studies on earthquake prediction, resources and evolution of the Arctic on the origin and emplacement of mineral resources and evaluation of the Arctic Ocean Basin, the adjacent Arctic Archipelago and the Canadian

Cordillera, including offshore regions, form a significant part of the work of the branch.

The Surveys and Mapping Branch is providing the basic framework for the national terrestrial science data base, and is continuing to satisfy increasing demand for positional data and mapping services, by the application of advanced technology. Some of the more significant Branch endeavours are as follows. The geodetic reference systems for North America are being redefined in cooperation with the U.S.A. and Mexico, so that earth scientists, surveyors and mapmakers will have a much improved basis for their work. Development of equipment specifications and positioning software will make the new NAVSTAR Global Positioning System applicable to all types of control surveys. Cost effective means are being developed for the automatic digitizing of topographic maps, so that digital data will be available and interchangeable between all levels of government and the private sector.

A computer-based capability for improving the usefulness of national atlas and aeronautical information is being developed. Legal Surveys of Canada Lands are being made more cost effective by the development of an integration of legal survey information with special mapping. A government-industry sponsored workshop on offshore surveys for mineral resource development will be held in early 1982. Technology transfer to the provinces and to industry continues to be a traditional activity of the branch.

The role of the Canada Centre for Remote Sensing is to improve the management of Canada's natural resources through the acquisition and use of earth observation data obtained from special sensors mounted on satellites and airborne platforms.

Data acquisition involves the development and operation, in cooperation with Canadian industry, of satellite ground receiving stations, airborne sensors and associated data processing systems. Use of the data for resource management purposes involves the development, in cooperation with industry and the provinces, of data analysis systems and methods to support applications such as forest management, mineral exploration, oil and gas operations in the Arctic, agriculture and environmental protection. Some of the centre's activities are thus also discussed in the Major Applications Section under Space, Natural Resources (Forestry and Minerals), Oceans and Food. The centre currently operates, in cooperation with industry, four specially-equipped aircraft and two ground receiving stations located in Prince Albert, Saskatchewan, and St. John's, Newfoundland, as well as advanced data analysis facilities in Ottawa, Ontario.

The department, through the Canada Centre for Remote Sensing, was the lead agency for the interdepartmental SURSAT program, which is responsible for the assessment of satellite systems for the surveillance of Canadian territory. An experimental program, regrouping over 100 prospective users was completed in 1980. The program demonstrated the potential of radar satellite data, operating irrespective of cloud, fog or darkness, to provide information related to the detection and location of human activity in the Arctic, coastal and ocean areas, as well as the surveillance of ocean pollution, land resources, and weather and sea state conditions. The SURSAT Program Board has thus recommended that Canada continue conducting, in cooperation with Canada's aerospace industry, a strong research and development program in the technology and applications of radar satellites. The RADARSAT program will emphasize sea-ice reconnaissance in support of Arctic petroleum operations, and will culminate in 1982 with recommendations to the government regarding Canada's options in the actual construction of such a satellite system.

Atomic Energy of Canada Limited

	Science Resources						Total Resources
	1980/81		1981/82		1982/83		1982/83
Program	S&T	R&D	S&T	R&D	S&T	R&D	
	(millions of dollars)						
Nuclear Research and Utilization	96.8*	78.8	114.2*	96.2	132.4*	110.5	357.8

* Excludes transfers from the program to other departments ($2.2 million in 1982/83).

Science expenditures by Atomic Energy of Canada Limited are estimated to be $132.4 million in 1982/83, an increase of 15.9% over 1981/82 forecast expenditures. Expenditures for R & D on the safe immobilization and disposal of radioactive materials from the operation of CANDU reactors are expected to amount to $34.0 million in 1982/83, compared to $17.5 million in 1981/82 and $16.0 million in 1980/81. Increased effort within existing resources will also be directed to developing new applications of reactor technology which could substitute for oil or improve the production of oil.

In 1978, Atomic Energy of Canada Limited was reorganized into a series of subsidiary companies with a corporate head office. With the exception of $12.5 million for feasibility studies related to the operation of Gentilly I reactor, all of the reported expenditures for science and technology are managed by the Research Company. The mission of the Research Company is to carry out basic and applied R & D in the field of atomic energy for peaceful purposes. The results of its R & D programs form the technological base for the engineering, chemical and radiochemical companies of the corporation and for other components of the Canadian nuclear industry. Five major objectives have been defined:

- to provide the basic scientific understanding essential to all technological advances in nuclear energy and related fields;
- to secure the nuclear option, through research and development on power-reactor systems, heavy-water production processes, radioactive-waste management, health and environmental effects of radiation, and safeguards;
- to develop new applications for nuclear energy, to help Canada resolve its major energy problem, a shortage of oil;
- to ensure a continuing supply of nuclear fuel for many centuries;
- to transfer nuclear technology to Canadian industry where it will be put to use for the benefit of Canadians.

Many of the Company's R & D programs contribute to several of these objectives while all contribute to technology transfer. The strength of the Research Company's R & D programs depends strongly on the operation of major research facilities, such as reactors, and the provision of services, including public information, many of which are unique to the operation of nuclear facilities in isolated areas.

These R & D programs are coordinated through an R & D program committee chaired by the Executive Vice-President, Research Company. Membership includes the site heads of the Chalk River Nuclear Laboratories (CRNL) and the Whiteshell Nuclear Research Establishment (WNRE), representatives of the other AECL operating companies, and key staff of the Research Company. Not a decision-making body, the program committee recommends programs to the President and Board of Directors, and then coordinates the programs which are approved. The R & D activities are subdivided into six major program activities:

- Power Reactor Systems;
- Advanced Fuel Cycles;
- Environmental Protection and Radioactive Waste Management;
- Heavy Water Processes;
- Underlying and Advanced Systems Research;
- New Applications.

Each program is coordinated through a steering committee chaired by a senior line manager. The program is subdivided into more specific work areas, each of which is usually coordinated by a line manager. The R & D program committee normally meets every second month for a formal review of the programs.

The Power Reactor Systems activity is concerned with R & D related to all aspects of the steam supply of nuclear generating stations: the reactors, moderator, fuel performance, heat removal, control and ancillary systems. Today the technology is often consolidated into computer programs which allow the designer, operator, manufacturer and regulatory agency to predict the behaviour of CANDU-PHW (Pressurised Heavy Water) reactors and their components over a wide-range of normal-operating and postulated-accident conditions.

The objective of the Advanced Fuel Cycles activity is to conduct research and assessment studies necessary to understand the technical and economic feasibility and the implications of the development and implementation of fuel cycle alternatives. The use of thorium in conjunction with fissile uranium or with plutonium produced in current fuel cycles could lead to a nearly self-sufficient fuel cycle and one that could be used in CANDU reactors thus avoiding the need to develop a new reactor concept such as the fast breeder reactor. Such a cycle promises a secure supply of low-cost energy for centuries. Experimental work is being carried out at the laboratory level, mainly to verify the feasibility of an economic thorium cycle.

Work in the Environmental Protection and Radioactive Waste Management activity continues to receive significant resources, as it has since 1978. Following a review of the Fuel Waste Management activity in April 1981, the government approved in principal a 10-year generic R & D program with specific funding approval for the period 1981/82 through 1983/84. Funding in 1982/83 will be $34.0 million. The goals are: to prove that reactor wastes and spent nuclear fuel and nuclear fuel wastes can be disposed of safely, and to develop methodology which can be used to assess the environmental and health effects of nuclear and other waste products (pathways analysis). The steering committee for this area also coordinates the development of safeguards against non-peaceful uses of CANDU technology.

The technology being developed for wastes arising from reactor operation (excluding used fuel) involves converting the wastes to a stable, leach-resistant form of bitumen. For the used fuel and fuel wastes, technology is being developed for: safe and economical storage of the spent fuel until reprocessed or disposed of; immobilization of the used fuel as is, or if the used fuel is processed, immobilization of the wastes in a leach-resistant matrix; and safe and economical isolation of the immobilized wastes from the biosphere for their hazardous life time. Work on interim storage is concentrated on dry-storage techniques as a feasible alternative to water-filled bays. Two options for immobilizing unprocessed fuel are being developed: the main emphasis is on a simple system that would provide immobilization for 300 to 500 years, and as a backup, an advanced system which would immobilize the fuel for a much longer period of time. The immobilization of separated waste in glass or other ceramics has been studied by several countries including Canada over many years. Current efforts are directed to the long-term effects of temperature, water and radiation on the glasses or ceramics that may be used.

The Canadian approach to disposal is concentrating on the possible use of stable geological formations, called plutons, found in abundance in the Canadian shield. The geophysical, geochemical and hydrogeological properties of various types of pluton are being determined in a program of test drilling at various sites in Ontario. To obtain the necessary understanding, a thorough investigation of different rock formations must be carried out using extensive drilling in granite and gabbro formations. Understanding will also be improved through large-scale experiments in the Underground Research Laboratory which is being constructed in a hard rock formation near the Whiteshell Nuclear Research Establishment in Manitoba.

The facility, as now envisaged, will consist of several small rooms at a depth of about 300 metres. A shaft will be used to gain access to the experimental level. The research program will provide information on the effects of excavation on the granitic rock mass and the hydrogeological behaviour in addition to a wide range of geological, hydrogeological and geochemical information in a rock formation typical of the Canadian Shield. It will also provide means to test thoroughly in a realistic environment the models and methodologies being developed to assess the overall concept of deep underground disposal. The laboratory will be the first test facility in the world which will be built below the water table and in an undisturbed rock formation. The U.S. and several other countries have expressed interest in participating in the project.

Work in the Heavy Water Processes activity concentrates on providing science and technology, frequently in the form of computer programs, which allow designers and operators to predict the performance of the GS heavy water process over a wider range of plant conditions. The improved predictive capability has increased production and lowered costs. The recently developed Hydrogen-Water Exchange processes are being investigated for use in heavy-water upgrading and for tritium removal. The first major application of this technology will be a tritium extraction system to be built at the Chalk River Nuclear Laboratories.

The objective of Underlying and Advanced Systems Research activity is to provide mission support, awareness of and response to new developments, assistance in emergencies and the basis for future progress. The Research Company has long-term programs in basic research aimed at increased scientific understanding in such areas as the health and environmental effects of radiation; the fundamental physics of radioactive and non-radioactive matter; the properties of materials; the chemistry involved in fuel development, waste management and nuclear systems; and advanced systems for the production of energy. Current effort in advanced systems research is aimed at: keeping electronuclear fuel breeding open as a long-term option; assessing long-term nuclear alternatives to fission power, particularly fusion; and developing shorter-term benefits from the associated technology.

Both the accelerator breeder and the fusion breeder are possible avenues to electronuclear fuel breeding. Both involve the production of neutrons which are absorbed in a uranium or thorium blanket to produce heat and fissile materials (fuel) for fission reactors. The heat generated would be used to produce electricity. At this time the technology for the accelerator breeder is considered to be significantly easier to develop than that for the fusion breeder. With respect to shorter-term benefits from the associated technology, a new accelerator—the turn-around LINAC—is now being marketed by the Radiochemical Company as a cancer therapy machine.

Within the New Applications activity, increased effort will be devoted to developing new applications of nuclear reactor technology which could substitute for oil, or which could improve the production of oil, such as from the Alberta tar sands. Substitution applications include the use of nuclear electricity in, for example, hybrid heating schemes and the production of hydrogen by electrolysis, the direct use of nuclear heat for industrial processes, and the use of inherently-safe small reactors for space heating. Other applications involve the use of waste heat from power reactors in greenhouses and fish hatcheries.

Department of Environment

Program	Science Resources						Total Resources
	1980/81		1981/82		1982/83		1982/83
	S&T	R&D	S&T	R&D	S&T	R&D	
	(millions of dollars)						
Administration	1.8	0.4	1.9	0.4	2.1	0.5	39.7
Environmental Services	232.7	86.6	263.2	99.7	316.6	118.7	442.2
Atmospheric Environment	115.8*	18.9	134.1*	22.6	164.8*	26.8	
Environmental Protection	8.8	5.4	8.2	5.3	10.0	7.1	
Environmental Conservation	57.8	16.8	62.6	18.3	72.4	21.0	
Canadian Forestry Service	50.3	45.5	58.3	53.4	69.4	63.8	
Parks Canada	12.6**	0.3	13.9**	0.4	15.4	0.4	277.9
Total	**247.1**	**87.3**	**279.0**	**100.5**	**334.1**	**119.6**	**759.8**

* Excludes funds transferred to other programs and departments ($2.7 million in 1982/83).
** Excludes funds transferred to other programs and departments ($0.2 million in 1981/82).

The department's total estimated expenditures for scientific activities in 1982/83 are $334.1 million, 44.0% of total departmental expenditures. The majority of the expenditures occur in the natural sciences under the Environmental Services Program ($311.1 million). This program is composed of the Atmospheric Environment Service, Canadian Forestry Service, Environmental Conservation Service (previously known as Environmental Management Service) and the Environmental Protection Service. Parks Canada's S & T expenditures on the other hand are almost entirely in the human sciences ($13.5 million).

The Department of the Environment pursues the following principal objectives:

- Conserve and enhance Canada's renewable resources for sustained economic and social benefit;
- Protect the environment from the adverse impact of human activities;
- Facilitate the adaptation of human activities to the environment;
- Safeguard, and foster public understanding and enjoyment of, Canada's natural and historic heritage;
- Increase resource productivity, through research and development in all aspects of forest management.

In addition to supporting these objectives, another objective of the S & T activities is to provide information services on natural hazards.

The Atmospheric Environment Service will spend $164.8 million in 1982/83 for scientific activities. Acquisition of meteorological data and weather, sea state and ice forecasting are major components of the science activity. The forecasting systems are supported by research programs designed to enhance these systems by, for example, numerical predictive modelling and improved remote sensing such as from aircraft, satellites, radar, and buoy systems.

Climatic information, in the form of historical statistics, near real-time monitoring and impact studies, along with the forecast information, is made available for planning and decision making regarding weather- and climate-affected Canadian activities in such sectors as agriculture, non-renewable energy exploration and renewable energy assessment, forestry, and fisheries. Research is undertaken to develop climate prediction expertise, to assess man's impact on climate and conversely the impact of climate on man.

Other research activities include programs related to atmospheric pollution, acid rain, the impact of man's activities on stratospheric ozone and toxic chemicals in the environment. R & D is also being undertaken to evaluate potential for rainfall enhancement in arid regions, and to assess wind and solar energy potential. Canada is an active member of the World Meteorological Organization and its science activities are supportive of international needs as well as our own domestic needs. Special contributions are being made to the Global Atmospheric Research Program, the World Climate Program, and the precipitation Enhancement Program.

With estimated expenditures in 1982/83 of $69.4 million, the Canadian Forestry Service promotes effective management and utilization of Canada's forest resources. Major programs deal with the development of environmentally benign methods of controlling pests and of improved firefighting equipment and techniques. Research is conducted in tree breeding to develop trees that grow faster and that are more resistent to pests, to support provincial reforestation programs. Under contract, research is conducted to support continuous modification of codes and standards for wood products, the application of computer technology to sawmilling and the evaluation of forest and factory residues for the economic production of various products. Other investigations concern wood properties, development of new adhesives from pulp mill wastes and development of new fire-retardant formulations. Research and development are proceeding on improving the recovery of valuable products from under-utilized species such as trembling aspen. A full-scale program is underway to develop forest biomass as an energy source, in particular to use mill and forest waste as raw material in the production of synthesis gas and other prepared fuels.

The Environmental Conservation Service is concerned with the wise and careful use of the country's wildlife, water and lands and with promoting the economic potential of renewable resources through wise management and development. The concerns are addressed through a variety of programs and activities designed to improve the understanding of Canadian resources, and encourage their use in a sustainable manner. By way of better understanding the relationships between resources, energy, technology and population, continuing effort is being placed on anticipating problems resulting from the impact of human activities on the environment. The Environmental Conservation Service conducts research in three main areas—inland waters, land and wildlife. The activities will involve an estimated expenditure of $72.4 million in 1982/83.

The Inland Waters Directorate is emphasizing the protection, restoration and enhancement of water quality to protect water users through the development of water quality objectives. The continuing Water Quantity Survey program measures streamflow, water level and sediment transport in Canadian waters. Studies of subsurface water quality at the National Hydrology Research Institute are focusing on factors important to disposal of highly radioactive materials at depths of about 1000 metres. Included in the studies is research on the physical and chemical factors controlling subsurface movement of contaminants. The Water Quality Monitoring program continues to assess the quality of the aquatic environment, particularly at transboundary locations.

The Lands Directorate pursues the conservation of Canada's land resource through the promotion of environmentally-sound and effective land-use practices. It supports and participates in land-related programs including: inventories of land characteristics, capabilities and use, formulation of land-use alternatives, and promotion of ecologically-sound land-use planning. It supports and participates in the research on ecological methods for land classification and the application of this research. The largest of the directorate's mapping programs is the Canada Land Inventory, which is concerned with land capabilities in the settled areas of

Canada. Over 1000 maps have been published. This data base provides a means of monitoring changes in land, of assessing Canada's land resource, and of evaluating effectiveness in conserving Canada's land resource.

The Canadian Wildlife Service is responsible for the protection and management of migratory birds through development of regulations, habitat management and research. With the provinces and other wildlife agencies, the service undertakes cooperative programs of research management and interpretation related to other forms of wildlife of national interest.

The Environmental Protection Service is the control arm of Environment Canada and is required to ensure that the government's responsibilities for the protection of the environment are consistent with national policy and that the appropriate legislative and regulatory requirements are enforced. The service is concerned with air and water pollution control, waste management including resource and energy conservation, contaminants control and environmental emergencies and ensuring that federally-funded or sponsored enterprises or activities are conducted in an environmentally-sound manner. In addition to its regulatory activities, the service has a leadership or advocacy role to ensure that the intent of Parliament is implemented, as expressed in legislation and regulations. S & T activities directly managed by the service in support of its responsibilities are estimated to cost $10.0 million in 1982/83.

The Department of the Environment is developing an environmental protection policy for the 80's with a focus on the control of toxic chemicals. The Environmental Protection Service has been designated as the focal point for the toxic chemicals management program and will oversee all departmental activities in the identification and assessment of problems associated with toxic or potentially toxic chemicals, including hazardous wastes and the actions needed to control them.

In accordance with its mandate to protect Canada's cultural heritage, Parks Canada carries on research designed to identify, preserve and develop national historic parks and sites throughout the country. This research, which is carried out at program headquarters and in five regional offices may be divided into the related fields of history, archaeology and architecture. S & T expenditures by Parks Canada in 1982/83 are estimated to be $15.4 million.

Canadian International Development Agency

	Science Resources						Total Resources
	1980/81		1981/82		1982/83		1982/83
Program	S&T	R&D	S&T	R&D	S&T	R&D	
	(millions of dollars)						
CIDA	36.5	8.6	40.4	9.7	45.0	11.1	943.7

The objective of the Canadian International Development Agency (CIDA) is to support the efforts of developing countries in fostering their economic growth and social evolution.

As can be seen from the table, CIDA's S & T activities, while substantial in themselves, are a small part of its total program. Many of the S & T activities occur in CIDA's Multilateral program which is concerned with giving aid to developing countries in concert with other agencies. For example, it has provided core funding to the International Rice Research Institute and to the International Centre for Research in the Semi-Arid Tropics. Other multilateral and bilateral agencies have also provided funding to assist in setting up these and other similar international institutes.

Under its Bilateral program the agency negotiates directly with individual developing nations to provide assistance. A case in point is where Canadian experts have helped the government of Kenya in its land use and sectoral planning, through studies of the interaction of wildlife and livestock in the rangelands.

The agency aids non-governmental agencies, such as OXFAM, which are active in the developing countries and which have contacts at the grass-roots or village level. These direct contacts can help to implement programs in ways that would be difficult if not impossible for more bureaucratic agencies.

International Development Research Centre

	Science Resources						Total Resources
	1980/81		1981/82		1982/83		1982/83
Program	S&T	R&D	S&T	R&D	S&T	R&D	
	(millions of dollars)						
IDRC	39.8	19.2	46.0	23.0	56.6	28.2	62.0

Estimated expenditures in 1982/83 by the International Development Research Centre are $56.6 million, an increase of $10.6 million or 23.0% over 1981/82 expenditures. The International Development Research Centre was established by Parliament in 1970 to intiate, encourage, support and conduct research into the problems of the developing regions of the world. It is also concerned with applying and adapting scientific, technical and other knowledge to the economic and social advancement of developing regions. In carrying out these objectives it:

- enlists the talents of scientists and technologists of Canada and other countries in both the natural and human sciences;
- assists the developing regions to build up the research capabilities, the innovative skills and the institutions required to solve their problems;
- encourages generally the coordination of international development research; and
- fosters cooperation in research on development problems between the developed and developing regions for their mutual benefit.

The centre was the first organization set up specifically to support research projects which are identified, designed, conducted and managed by developing-country researchers in their own countries, in the context of their own priorities. Although it obtains funds by Parliamentary vote and reports annually to Parliament, its operations are guided by an international and autonomous Board of Governors.

The centre, through its four program divisions — Agriculture, Food and Nutrition Sciences; Health Sciences; Information Sciences; and Social Sciences — offers direct grants to institutions or individuals. It does not offer conventional technical assistance or capital grants for large scale development programs. Its relatively-small awards (average grants of $187,-000) enable the recipients to secure the best available professional skills and finance projects in the most effective way, without regard to the source of the resources used.

Projects submitted to the centre for funding are initiated by the applicants and channelled through representatives of the program division concerned either in Ottawa or in the centre's regional offices. Each project brought to the attention of the director of the program division and submitted to the Board of Governors for final approval is considered under such criteria as: the need for and practicality of the research, the applicability of the research findings to as wide an area as possible, the use of local resources, and the potential for training local researchers and developing local research institutions through the project. Research institutions conducting the work have full responsibility for project administration and control. Program representatives make regular visits to project sites and can provide assistance should the need arise.

In April 1981, the centre launched its Cooperative Programs Unit to give developing countries greater access to Canadian R & D capabilities. The program will respond to requests for collaborative research made either directly by developing countries, or in association with or through Canadian institutions.

During the United Nations Conference on New and Renewable Sources of Energy held in Nairobi, in August 1981, the Centre was invited by the Federal Government to support more energy research in developing countries. It is likely that Centre-supported research will focus on three areas: support for research to define energy problems in developing countries; research to identify and evaluate energy technologies; and, research to improve energy planning.

Department of Fisheries and Oceans

Program	Science Resources						Total Resources
	1980/81		1981/82		1982/83		
	S&T	R&D	S&T	R&D	S&T	R&D	1982/83
	(millions of dollars)						
Fisheries and Oceans	116.4	56.7	130.0	63.2	145.8	64.0	481.9

The Department of Fisheries and Oceans was created by an Act of Parliament in April 1979. The new department has assumed responsibilities for fisheries, fisheries research, oceanographic research, hydrographic surveys and charting of navigable waters. The estimated S & T expenditures in 1982/83 will amount to $145.8 million, of which $18.3 million will be spent extramurally.

The general objectives of the Ocean Sciences and Surveys activity are as follows.

- To conduct, on a national basis, research programs in physical, chemical and biological oceanography and limnology with the aims of: gaining a better understanding of the marine and freshwater environments; utilizing the information to define and help solve real and potential problems; responding to national concerns; and providing information and advice as a service.
- To support, through these programs, the management of marine and freshwater resources; the enhancement and protection of marine and freshwater environmental quality; and the safe, orderly, and efficient conduct of shipping in Canadian waters and in those areas of open ocean of direct interest to Canada.
- To contribute to the national capability in fisheries and marine science, through the development and transfer of ocean technology, the management of contracts pertaining thereto, the provision of direct financial aid to qualified university research projects (subvention program), and the implementation of a national fisheries and marine information and publications policy.
- To ensure that adequate hydrographic data, charts, and publications are available as and when required to meet the needs of navigation in all Canadian waters, including the re-surveying of all areas where existing surveys do not meet today's requirements.

The Department is considering the establishment of an Ocean Climate Program to describe and predict changes in the ocean and to assess the impact of these changes on our fisheries. The program will cover physical and chemical oceanographic research, as well as biological research and pilot studies on the impact of changes in the ocean climate on fish migration, abundance and availability.

Commercial activity in the Arctic has increased enormously in recent years, as a result of new and expanded hydrocarbon and mineral exploration. S & T efforts are being directed to marine transportation and to environmental issues, in particular, to provide information on the inter-relationship of marine life resources and the physical, chemical and biological environments of Arctic Waters.

The Fisheries Management and Research activity of the department is organized into two distinct responsibility areas. The first of these is Fisheries Economic Development and Marketing, which is responsible for fisheries marketing, export development and industrial policy development. In addition to a mainly economic and policy development task, industry technological development, policy research data development and economic research are also pursued. Research is conducted into such major fisheries economic issues as the economic and social impacts of alternative management systems, changes in harvesting and processing technology, changes in prices of fuel and other inputs, the impact of acid rain and offshore oil and gas developments, and impact of changing markets for fish. These activities are conducted in cooperation with economists in the regional offices across Canada.

The second responsibility area covers fisheries management and research programs which are organized into two main regional groups. Activities in Newfoundland, the Maritime provinces and Quebec are grouped under the Atlantic Fisheries Service, while those in Ontario, Western and Pacific regions are grouped under the Pacific and Freshwater Fisheries program.

Responsibility for fisheries research on a national basis is vested in the Assistant Deputy Minister, Atlantic. Both groups will be responsible in their respective areas for:

- resource assessment and prediction and related research, including analysis of alternative resource management policy;
- resource enhancement and aquaculture;
- habitat protection and related research;
- resource allocation for optimal social and economic resource utilization;
- supply management of the resources;
- development of harvesting technology;
- research on improving fish quality;
- fishing fleet development and development of policies and plans for fleet deployment;
- provision of statistical data and analysis on catches, fishing effort, prices, costs and incomes;
- collaboration with the Ocean Science and Surveys activity, other federal departments and agencies, universities, industrial and fishermen's organizations, provincial governments, international commissions and the industry and governments of other countries.

Department of Industry, Trade and Commerce

	Science Resources						Total Resources
	1980/81		1981/82		1982/83		1982/83
Program	S&T	R&D	S&T	R&D	S&T	R&D	
	(millions of dollars)						
Trade-Industrial	95.9	92.0	142.0	135.9	171.9	165.2	576.7
Tourism	0.3	—	0.4	—	0.4	—	43.2
Grains and Oilseeds	1.2	1.2	1.1	1.1	1.1	1.1	146.8
Total	**97.5**	**93.2**	**143.5**	**137.0**	**173.3**	**166.3**	**766.6**

The S & T objectives of the Department of Industry, Trade and Commerce are to stimulate innovation and to promote the use of modern technology in Canadian industry.

Most of the department's S & T expenditures are made through the Trade-Industrial Program. It is estimated that in total the Trade-Industrial Program will spend approximately $171.9 million for S & T activities in 1982/83, an increase of $29.9 million or 21% over 1981/82 forecast expenditures.

One of the major activities in this program is the Enterprise Development program (EDP) whose overall objective is to help the growth of the manufacturing and processing sectors of the Canadian economy. The thrust of the program is to foster innovation in the design and development of new or improved products or processes. The focus is on promising small and medium-sized firms prepared to undertake relatively high-risk projects which are viable and promise attractive rates of return. EDP provides support to eligible firms by sharing project costs. Rights to the technology are vested in the company but the commercial exploitation of the project results must be undertaken in Canada. Forecast expenditures for 1981/82 are $80.3 million, an increase of $26.7 million over 1980/81. It is estimated that expenditures will increase to $94.4 million in 1982/83, including $15.7 million in assistance to the electronics industry via the Special Electronics Fund.

Under the Special Electronics Fund the Microelectronics Support Program (MSP), instituted in 1981, is designed to assist Canadian companies with the initial use of microelectronics in their operations or products. In conjunction with the MSP, microelectronics centres of technology have been established at six Canadian universities.

The Defence Industry Productivity program is another major industry support program which is intended to sustain the technological capability of the Canadian defence industry for the purpose of generating economically viable defence exports and related civil exports arising out of that capability. Estimated S & T expenditures for 1982/83 are $64.4 million compared to $54.2 million in 1981/82 and $37.6 million in 1980/81.

The Industry Energy Research and Development program was introduced in 1978/79 to encourage and assist Canadian industry to undertake research and development of new and improved processes and equipment that will reduce energy consumption. Annual expenditures on this program have been $1.5 million, but are estimated to grow to $7.0 million for 1982/83, with additional funds for the National Energy Program.

The Institutional Assistance Program (IAP), assists in the establishment of non-profit organizations to provide R & D and other specialized technical services under contract to industrial and other clients. The estimated expenditures of the IAP in 1982/83 are $4.2 million. Under this program, the department supports individual institutes and centres for a maximum of 8 years after which they are expected to become self-supporting. Of the 23 centres and institutes established and now in operation, 15 are now financially self-sustaining.

The Industrial Research Institute element of the IAP assists in the establishment of organizations at Canadian universities which arrange for university faculty to provide contract research and technical services to industry. Nine industrial research institutes are now in operation.

The Centres of Advanced Technology element assists universities, provincial research organizations and other non-profit institutions to develop and maintain a special competence in a specific field of technology and to provide, under contract with industry, assistance with development projects as well as training and evaluation services relating to that technology. Twelve centres of advanced technology are now in operation.

The Industrial Research Association element assists groups of firms to undertake cooperative research on common technical problems. Four industrial research associations are now in operation.

The Industrial Innovation Centre element provides assistance to two centres associated with the University of Waterloo and École Polytechnique of Montreal. These centres facilitate the commercialization of new products and the establishment of new technology-oriented businesses.

Under the Institutional Assistance Program, the department also supports studies and awards scholarships in the practices and management of technological innovation. The Program supplies the department with information on technological innovation which is needed to develop programs or policies to promote the innovative performance of Canadian industry and to encourage continuing academic interest in an area of vital importance to Canadian economic growth.

The S & T activities in the department's Tourism Program involve in-house economic studies of the tourism industry. The Grains and Oilseeds Program has provided assistance for the establishment and continued operation of the POS (Protein, Oil and Starch) Pilot Plant in Saskatoon. The pilot plant offers facilities to industry on a contractual basis for the development of processed products from vegetable sources. Also funded through the Grains and Oilseeds Program is the Canola Utilization Assistance Program operated by the Canola Council of Canada. This program provides assistance to research designed to increase the commercial utilization of Canola (rapeseed).

On January 12th, 1982 the Prime Minister announced that the industry, small business and tourism components of this Department would be amalgamated with the regional program of the Department of Regional Economic Expansion to form a new Department of Regional Industrial Expansion. The trade side of the Department of Industry, Trade and Commerce will be transferred to the newly-restructured Department of External Affairs, The Department of Consumer and Corporate Affairs will take over the Metric Commission and the Standards Council of Canada. These changes are not reflected in the structure of the 1982/83 main estimates; accordingly they are not reflected in this report.

Department of National Defence

Program	Science Resources 1980/81 S&T	Science Resources 1980/81 R&D	Science Resources 1981/82 S&T	Science Resources 1981/82 R&D	Science Resources 1982/83 S&T	Science Resources 1982/83 R&D	Total Resources 1982/83
	(millions of dollars)						
Defence Services	102.6*	99.8	112.0*	108.8	139.6*	136.0	7,356,6

* Excludes transfer of funds to other departments ($9.9 million in 1982/83).

The Department of National Defence's estimated expenditures for scientific activities in 1982/83 are $139.6 million, up 24.6% from 1981/82. Its S & T program is aimed at improving the operating capability of the armed forces by the effective application of science and technology to all departmental functions, ranging from strategic policy decisions through military operations to the maintenance of effective personnel and material resources. The analysis of new technological developments and their impact on operations is an essential element in the timing and selection of equipment acquisitions. The department depends, in part, on the R & D activities of other government departments and agencies and of Canadian industry, and on the sharing of S & T information with Canada's allies.

The department's intramural R & D program contributes to the international sharing of S & T information and provides the knowledge base for the application of S & T to equipment acquisitions and operations. Research in the natural sciences is conducted at six Defence Research Establishments at various locations across the country and the program comprises three elements: Human Protection and Performance, Sensors and Electromagnetics, and Ordnance and Vehicles.

Human Protection and Performance covers a wide spectrum of scientific disciplines that relate to the interaction of the soldier and the environment(s) in which he or she will be expected to live and operate. Approximately half of the total resources of this group are devoted to the protection of the soldier against adverse environments, whether natural or artificial, including nuclear, biological, chemical, high altitude and deep ocean environments. The major concern, however, is protection against chemical warfare agents. Protective ensembles have been developed for general purpose as well as for the crews of high performance aircraft. Other concerns are protection against extremes of cold and heat. Another important research activity is concerned with the effectiveness of the man/machine interface and involves studies of anthropometry, vision, hearing vibration and human-engineering aspects of equipment design. Recently a program of research has commenced on the human performance aspects of command and control, simulation and training and sustained operations.

In-house programs in Sensors and Electromagnetics include research in underwater acoustics, electronic warfare, electro-optics, navigation, magnetics and command and control systems. In addition the Communications Research Centre of the Department of Communications carries out contracted and cooperative work on radar and communications. These activities are growing and demanding an increasing share of the total R & D resources. Results from this research assist in the choice of off-the-shelf purchases or development in Canadian industry of sensor, navigation and communications systems for a wide variety of military operations and on major platforms such as the Long Range Patrol Aircraft, the New Fighter Aircraft and the Canadian Patrol Frigate. Associated electronics systems needed to counter hostile systems, and also to improve the survivability of expensive military platforms, have been receiving increasing attention. A growing effort is occurring in space activities where significant increases in capability for surveillance, accurate navigation and communications are possible. The major activities are in the search-and-rescue satellite (SARSAT) project, the satellite-based global positioning system NAVSTAR program, ground communications terminals and vehicular communications terminals.

Ordnance and Vehicles activities include R & D programs on ordnance, hydronautics, energy conversion and conservation, materials services, and mobility, countermobility and combat engineering technologies. In addition, there is an extramural program in aeronautics which supports research and design capabilities in

Canadian industry. A new extramural activity is planned in aeropropulsion (gas turbine technology), to be located at the National Research Council: a small center of expertise will be established to address life cycle maintenance management and operational details of aircraft engines in Canadian Forces services. Ordnance remains the largest in-house program, utilizing approximately half the available personnel resources. The major activity in this area is in support of the CRV-7 Rocket Weapon System (2.75-inch diameter air-to-ground rocket), for which the motor is being produced by Bristol Aerospace Limited; the first offshore sales of this rocket were made last year to Malaysia and other sales are anticipated. A new activity introduced at Defence Research Establishment Suffield involves aerial target and remotely-piloted-vehicle technology; initial emphasis is on targets for ground-to-air gunnery and missile training. Work is planned in mobility fuels in cooperation with the Department of Energy, Mines and Resources and other government departments towards objectives of the National Energy Program.

The department is employing social sciences in its research program to an increasing extent. The Operational Research and Analysis Establishment (ORAE) possesses capabilities for strategic studies and social and economic analysis, as well as for operational research and systems analysis. Areas of study include methods of averting war by deterrence and arms control; socio-economic analyses to evaluate the impact of military forces on the society in which they operate; and analytical studies of logistics and manpower problems. The operational research studies in the establishment generally relate to the effectiveness of weapons and weapon systems and of military procedures for using them. Although most of this work is carried out in-house, some specific studies are contracted-out.

Department of National Health and Welfare

Program	Science Resources						Total Resources
	1980/81		1981/82		1982/83		1982/83
	S&T	R&D	S&T	R&D	S&T	R&D	
	(millions of dollars)						
Administration	6.0	—	8.1	—	9.0	—	39.9
Health and Social Services	17.3	6.3	18.7	6.7	18.6	5.7	6,701.9
Medical Services	2.1	2.1	3.9	3.9	2.2	2.2	244.5
Health Protection	38.0	11.2	41.3	12.4	50.3	15.4	92.5
Income Security	0.5	—	0.6	—	0.9	—	12,286.0
Total	**63.8**	**19.6**	**72.6**	**23.1**	**80.9**	**23.3**	**19,364.8**

The scientific activities of the department support its primary missions of promoting and preserving the health and social welfare of Canadians. The department exercises leadership in the health and social welfare fields by developing and enforcing national standards of quality and safety in foods, drugs and medical devices, by identifying and developing ways to reduce or eliminate physical, chemical and biological threats to health, by finding ways to improve individuals' awareness and concern for factors that affect their health and social well-being, and by encouraging the experimental development of new or improved systems for delivering health and social services.

The accompanying table shows the resources that are devoted to scientific activities within the department's five budgetary programs.

The science resources ($9.0 million in 1982/83) identified within the department's Administration Program are almost exclusively those of the Policy, Planning and Information Branch, which serves as a support to the line branches. About one third of these resources support departmental policy development (for example, in relation to income security) through quantitative analysis and policy analysis, involving applied human sciences. The remainder of these resources are devoted to the development and improvement of computerized health and social welfare information systems and data banks. The data is obtained both from surveys and from the administrative files of the federal and provincial governments. The program includes a $2 million contributions fund to assist provincial departments to upgrade their information systems and to develop nationwide compatibility among them.

Most of the scientific activities ($18.6 million in 1982/83) that are supported in the Health and Social Services Program are carried out extramurally. Among the science resources reported for this program are the Family Planning Grants, which assist in the development of provincial, municipal and voluntary family planning services and support projects which ensure the accessibility of family planning services to all Canadians who want them. They also support research and research training in family planning and provide demonstrations of the need for and methods of delivering family planning services as well as university fellowships for research in family planning, which includes both demographic and behavioural studies.

Through the Mental Health Division of this Program, the department has funded an epidemiological profile of suicide and suicide attempts in Canada as well as an analysis of suicide preventive strategies. A Suicide Task Force report expected in 1982 will analyse these and other research findings, and provide guidelines and/or recommendations for appropriate action at federal, provincial or regional levels. At the request of the National Indian Brotherhood, the Mental Health Division is also funding, in collaboration with Medical Services Branch, a preliminary study of successful suicide prevention programs among Indian people. Also funded by the Mental Health Division are regular symposia and task group meetings of mental health scientists and planners from provincial and academic institutions to plan joint activities in the area of scientific inquiry and program development. In 1981/82, the Division will hold a symposium on past and current research related to psychological impacts of resource development on the indigenous and immigrating populations of frontier communities faced with rapid expansion.

A major vehicle for science and technology in social development is the Social Services Development and Grants program. Its objective is to promote improvements in welfare services and self-help activities, by providing financial assistance, consultation, information and advice to governmental and non-governmental welfare agencies, including citizen organizations and universities, to enable them to carry out short-term research and demonstration projects and other S & T activities, and by providing financial assistance to individuals for advanced studies in social work. To enhance the department's vitality and strategic role in the social welfare field, the program in 1982/83, will strive to ensure the federal presence and visibility in all regions, provide a reasonable distribution of its resources according to needs evident in the field, provide financial assistance and consultation to the major partners in the social welfare field, with particular emphasis on the non-profit/voluntary sector, and ensure that the information secured through its activities reaches those who need and can use it, both within and outside the department. Contributions will support studies, research, field experiments, human resources development, seminars, conferences and other related scientific activities in the social services field. In particular, the aged, the poor, native people, women, children and families, and the disabled will receive special attention.

Several hundred researchers, assistants and technical personnel working outside of the federal public service are supported by the above programs and by the National Health Research and Development Program, which accounts for slightly more than half of the science resources within the Health and Social Services Program. It supports research and development as well as related scientific activities such as data collection and analysis, demonstration projects, the formulation of proposals, and conferences. Fellowships for research training and awards for career scientists complete the range of functions designed to support the department's responsibilities in the health field. The National Health Research and Development Program is presently encouraging research on chemical, physical and biological hazards to health in the home, workplace and natural environments, on primary and secondary illness prevention, including the development and evaluation of physical and mental health promotion strategies, on the extent to which existing and proposed health care policies and practices do or may impact on the availability, accessibility and quality of health care, on factors which contribute to perinatal and childhood mortality and morbidity and strategies for the reduction of these states, and on the needs and special problems of special groups, such as the elderly, native people, the handicapped and the disabled.

Also within the Health and Social Service Program are scientific activities carried out by the Health Promotion program, designed to assist in developing and assessing its health promotional activities. Examples are: a national survey of smoking habits of Canadians, evaluation of the Dialogue on Drinking Campaign, analysis of pre-natal records as a means of developing alternative systems for pre-natal care, and a survey of Cannabis use.

Exclusive of transfer payments, the Medical Services Program is the largest program of the department. Laboratory and investigative activities carried out in support of services in the Civil Aviation Medicine, Occupational Health and Environmental Contaminants components of the program have all been identified as scientific activities ($2.2 million in 1982/83). Also included are those science resources associated with the Northern Medical Research Unit, which carries out health and nutrition surveillance studies in the Northwest Territories, and investigates diseases and environmental contaminants of northern wildlife which may affect the health of northern residents.

The Health Protection Program ($50.3 million in 1982/83) contains the Food, Drugs, and Environmental Health Directorates, the Field Operations Directorate, and the Laboratory Centre for Disease Control.

The Field Operations Directorate has two main roles in contribution to the programs of the Health Protection branch. The first role, as the compliance arm of the Branch, is to minimize health hazards by ensuring that industry complies with regulations and product standards aimed at the production of safe foods, drugs and medical devices. The second role is to provide technical services to other government departments, other Health Protection Branch directorates, and to the public.

To carry out these roles, the Field Operations Directorate has an organization consisting of a small headquarters staff, with professional and support staff located in Halifax, Montreal, Toronto, Winnipeg and Vancouver, and 22 associated district offices. To develop and conduct compliance programs, the directorate staff carries out inspections, investigations, sampling and analysis, education, and enforcement activities such as prosecutions, recalls and seizures. The inspection and analytical data provided as a technical service to the other branch directorates is used to determine program priorities and to develop regulations and product standards.

In the Food Directorate, scientific activities protect the public against deficiencies in the nutritional quality of foods and from microbial and chemical hazards that might cause illness. Major organizational units are the bureaux of Chemical Safety, Microbial Hazards and Nutritional Sciences. The Food Directorate works together with the Field Operations Directorate in administering the food provisions of the Food and Drugs Act. Research divisions carry out studies in such fields as: microbial hazards in food; the toxicology and food chemistry of food additives, contaminants and components; the nutrient composition of food, nutritional status and bioavailability and effects of nutrients; and the development of analytical methods for use in monitoring and surveillance. Scientific evaluation divisions exert influence on food safety through contributions to the development of policies, guidelines and regulations that take account of data from research and regional laboratories and from detailed review of industry submissions (e.g., regarding the use of food additives and agricultural chemicals). The risks and benefits of chemical use and of other changes in foods and eating habits are issues for which a scientific basis for decision is provided.

The Drugs Directorate consists of seven bureaux: Drug Quality, Dangerous Drugs, Human Prescription Drugs, Non-Prescription Drugs, Veterinary Drugs, Biologics, and Drug Research. The directorate is responsible for ensuring the safety and efficacy of human and veterinary drugs which are manufactured or offered for sale in Canada, as well as for the safety of cosmetics. New drug submissions and applications for proprietary medicines are evaluated nationally for their safety and efficacy, and also with respect to manufacturing and labelling aspects. The directorate also licenses vaccines and other biological drugs for manufacture and sale. Surveillance programs are carried out to assess the safety, efficacy, pharmaceutical quality, advertising and manner of use of marketed drugs. It also carries out programs to control the misuse and abuse of drugs, particularly psychoactive ones, and to provide information to health professionals and to the general public on the quality and the wise use of drugs.

The Drugs Directorate maintains the Bureau of Drug Research which carries out investigations in fields of toxicology (e.g. carcinogenicity, mutagenicity, allergenicity) and of pharmaceutical chemistry and develops analytical methods in these fields. This laboratory expertise enables the directorate to make informed decisions on drug safety, efficacy, and quality. As the complexity and sophistication of the scientific knowledge underlying newly-available products increases, together with the number of multidisciplinary involvements, the ready availability of scientific expertise within the regulatory agency itself becomes even more essential. The Bureau of Drug Research consists of five divisions: Pharmaceutical Chemistry, Drug Identification, Chemical Standards, Drug Toxicology and Scientific Services. One of the main functions of the bureau relates to drug standards and the development of assay methods for synthetic drugs, for drugs of natural origin, and for impurities in drugs. Special attention is paid to the detection of impurities which, when discovered, are submitted to toxocological assessment to enable specifications to be set for their control.

The Environmental Health Directorate identifies, assesses and takes steps to reduce health hazards associated with the physical, chemical and technological components of natural and man-made environments. Its main program areas are directed toward the control of chemical hazards associated with consumer products, drinking water, pesticides and other contaminants of natural and man-made environments; radiation exposures associated with nuclear installations; the diagnosis and treatment of disease in occupational settings; and the quality and effectiveness of medical devices.

The Environmental Health Directorate participates in:

- the International Joint Commission, in assessing health hazards from Great Lakes contaminants;
- the Organization for Economic Cooperation and Development, in standardizing toxicity tests;
- the North Atlantic Treaty Organization, in assessing drinking water quality;
- the United Nations Scientific Committee on the Effects of Atomic Radiation, in assessing radiation effects on humans.

The directorate has entered into commitments with the World Health Organization to become a lead institution for international programs on drinking water and pesticides, within the new International Program on Chemical Safety.

Medical devices utilizing the newest advances in engineering, materials and micro-electronics have revolutionized health care in recent decades. The Bureau of Medical Devices is conducting research into the health effects, risks and benefits from several new device classes such as automated insulin delivery systems, vascular prostheses, replacement heart valves, synthetic blood for emergency transfusions, plasmapheresis units and in vitro diagnostic tests for the detection and monitoring of several major diseases. The information generated for both manufacturers and users leads to improved quality and utilization of devices. In cooperation with hospitals, physicians, coroners and other health professionals, investigations are continuing into the incidence and causes of device-related morbidity and mortality with the objective of reducing these risks. Several classes of devices which have a potential of severe adverse reaction or life-threatening failure will be subject to pre-market review to evaluate their safety and effectiveness and to develop criteria of acceptability. In addition, the Bureau is taking a leading role in developing safety and performance standards for a number of critical devices such as infant incubators and anaesthesia machines.

The Laboratory Centre for Disease Control is mainly a service-oriented directorate, whose primary function is to provide epidemiological information, microbiological data, and diagnostic reagents to provincial governments, hospitals and laboratories.

The directorate provides a national focal point and liaison in epidemiology and microbiology to international organizations, including the World Health Organization, Center for Disease Control in the United States, and the Public Health Laboratory Services in England.

The Centre for Disease Control has five scientific bureaux: Epidemiology, Infection Control, Medical Biochemistry, Microbiology, and Tobacco Control and Biometrics. The two disease surveillance bureaux, Epidemiology and Infection Control, monitor the incidence and causes of disease in Canada. They provide epidemiological assistance in epidemic situations and coordinate strategies for the control and prevention of communicable and non-communicable diseases. They also provide a surveillance system to study factors as potential causative agents in congenital anomalies, adverse reaction to drug products, and acute poisoning. In the field of infection control, special programs are designed to assist in reducing the high toll of hospital and laboratory-acquired infections.

The Medical Biochemistry and Microbiology Bureaux provide services to assist provincial and clinical laboratories in the diagnosis and treatment of disease. National reference centres are located in-house and in specialized laboratories across Canada. These provide specialized diagnostic reagents for, and direct identification and characterization of, specific causative agents of diseases such as bacteria, viruses and parasites.

The Tobacco Control and Biometrics Bureau develops alternative federal regulatory policies concerning the manufacture, importation, distribution, sales and use of tobacco products and psychotropic drugs, together with the provision of advice on statistical design and analysis of directorate projects, experiments and surveys.

The scientific activities ($0.9 million in 1982/83) under the Income Security Program all involve aspects of the human sciences, such as: development of population and cost projections; the development and analysis of beneficiary surveys; program statistical data bases; and micro and macro socio-economic studies of the impact of existing programs and of proposed changes to them.

Medical Research Council

Program	1980/81 S&T	1980/81 R&D	1981/82 S&T	1981/82 R&D	1982/83 S&T	1982/83 R&D
	Science Resources (millions of dollars)					
Grants and Scholarships	80.4	78.1	98.4	95.2	110.9	107.3
Administration	1.6	1.4	1.8	1.6	2.0	1.8
Total	**82.0**	**79.5**	**100.2**	**96.8**	**112.9**	**109.1**

All of the Medical Research Council's expenditures are for S & T activities. As contained in Main Estimates, the council's expenditures for 1982/83 are estimated to be $112.9 million, 12.7% higher than in 1981/82 and 37.7% higher than in 1980/81.

The objective of the Medical Research Council is to help attain the quality and scale of research in the health sciences essential to the maintenance and improvement of health science services. The council has articulated a number of sub-objectives:

- to expand the scientific and technological base for health care;
- to improve the application of scientific principles to health care;
- to ensure an adequate research base for education in the health sciences;
- to support the training of researchers in the health sciences; and,
- to support research contributing to new knowledge in the health sciences.

The council's objective implies a strong federal presence in the support of health research in Canada. However, there continues to be long-standing cooperation between the council and other federal, provincial and voluntary agencies. The growth of various non-profit agencies supporting elements of Canadian medical research has allowed the council to develop its primary role as a supporter of fundamental research and training of health science researchers. The council also collaborates with other funding agencies to develop concerted thrust areas as shown in its continuation and expansion of support in the fields of heart research, perinatology and generally in the clinical application of existing knowledge.

Nearly 97% of the council's grants budget is used to support research, research training and related scientific activities in Canadian universities. This support is provided under a number of programs which include:

- the Grants program, which provides grants for research by individuals and groups;
- the Subject Research Development Grants program, which provide support in areas of not only national concern but also with the potential to respond to special initiatives; and,
- the Development Grant program, whose purpose is to strengthen university research in health science in those regions where the level is considered inadequate to serve the needs of health care and professional education.

The remainder of the grants budget is used to support Canadians undertaking research training or specific research projects in other countries, with a small amount for the support of international scientific organizations in the health sciences.

In supporting research, the council strives to achieve both a balance and an effective integration between targeted or "applied" research and basic research leading to a better understanding of the fundamental biological processes in health and disease. Thus, no proposal for basic research goes unscrutinized by competent scientists who can assess the potential for clinical application of the results. Similarly, applied research proposals are carefully assessed to assure the validity of the proposed methodology.

National Research Council

Program	Science Resources					
	1980/81		1981/82		1982/83	
	S&T	R&D	S&T	R&D	S&T	R&D
	(millions of dollars)					
Scientific and Industrial Research	211.4*	190.0	278.8*	255.0	339.0*	312.4
Scientific and Technical Information	14.7	—	18.6	—	21.7	—
Total	**226.1**	**190.0**	**297.4**	**255.0**	**360.7**	**312.4**

* Includes net of transfers to and from other departments ($1.8 million in 1982/83).

The National Research Council of Canada is a departmental crown corporation with a governing council, consisting of a President and 21 members appointed by the Governor-in-Council. The council's estimated expenditures for 1982/83 are $360.7 million, an increase of 21.2% over the 1981/82 figures. The council has a broad mandate, "to promote, assist and undertake scientific and industrial research" for national development. This mandate is pursued by means of a broad spectrum of activities which include research in scientific and engineering fields in response to national, economic and social needs in areas such as transportation, energy, food, building, construction, industrial innovation and development, health, security, safety and environmental quality.

The council's laboratories are located mainly in the national capital region, but substantial regional operations exist or are being established in British Columbia, Newfoundland, Nova Scotia, Quebec and Saskatchewan. Brief descriptions of the regional laboratories are given in the Regional Expenditures section. The council opened a Fire Research Field Station in 1980 near Carleton Place, Ontario, about 60 kilometres west of Ottawa. It is a versatile facility for carrying out full-scale experimental studies of fire situations in buildings. The facility will be used primarily for research, but its services may be available, as circumstances permit, for use by other government agencies and the private sector.

The council's current activities are carried out within two budgetary Programs; the Scientific and Industrial Research Program and the Scientific and Technical Information Program. The Scientific and Industrial Research Program (which will spend $339.0 million in 1982/83) is made up of seven elements: basic and exploratory research; research on long-term problems of national concern; research in direct support of industrial innovation and development; research to provide technological support to social objectives; research and services related to standards; the management of national facilities as a service to industry, governments and universities; and the provision of administrative and special support services for the council.

The Scientific and Technical Information Program (which will spend $21.7 million in 1982/83) is centered on the Canada Institute for Scientific and Technical Information. The institute provides a wide range of information services to the government and university and industry sectors, including access services to published material in the world's scientific literature and the delivery of information from computerized data bases. Scientific and technical information (STI) services are an essential adjunct to R & D in that they support its performance, help researchers to avoid unnecessary research, and disseminate research results world-wide. Increased activity in R & D automatically generates increased demands for STI services. The council's activities in this field area are also described in the Major Applications section—Scientific and Technical Information.

Industrial Programs

The NRC has had industrial responsibilities from its beginning in 1916 as the Advisory Council on Scientific and Industrial Research. When the Laboratories were founded, the bulk of the work was in industrial or applied science fields; representatives of industry and business served then, as now, on the Council alongside university professors and NRC staff.

In the last 20 years the council's industrial programs have been increased and formalized into a number of discrete activities. In addition, some parts of the laboratories and of the information services have taken on distinctly industrial orientations. In financial terms, the council now disburses more than $85 million a year for research performed by industry. There are also joint industry-council projects, examples being the broad programs of the Industrial Materials Research Institute (IMRI) in Montreal and the construction of the Remote Manipulator System (the CANADARM) for the U.S. Space Shuttle. Today, the Council's Industrial Development Office is divided into two major sections, the Industrial Research Assistance Program (IRAP) and the Program for Industry/Laboratory Projects (PILP).

The Industrial Research Assistance Program (IRAP) was established by the government in 1962 to encourage applied research by Canadian industry. The program has as its objective the increase in calibre and scope of industrial research in Canada, particularly where it leads to high business effectiveness and economic benefits.

Originally this was achieved by providing scientific and technical advice and financial assistance for research carried out in industrial laboratories. In 1981, the program was consolidated with the addition of the older Technical Information Service, and also reinforced with some additional programs, all to give effect to an expanded objective of raising the level of technology in Canadian industry with the help of scientific and technical knowledge available in government S & T establishments, in particular, those of the National Research Council. Companies will be encouraged to work with provincial research organizations, research institutes, and other specialised organizations, as well as with the council's research staff.

The previous policy of providing financial assistance for projects that increase the calibre and scope of industrial research will continue. Additionally companies will be encouraged to make more extensive use of the Technical Information Service (TIS) element of the Industrial Research Assistance Program (IRAP), not only for problem-solving, but also to assist in making decisions on applications for financial support.

The six elements of the new consolidated IRAP office are as follows.

The Field Advisory Service (FAS) is the spearhead of the program, with some 60 to 70 field service officers located at strategic points across Canada. Officers provide liaison between the council and the company, as well as assist the sub-program managers in identifying needs, assessments of proposals, and evaluation of results. The Technical Information Service (TIS) is the central advisory service located in Ottawa. It is staffed by a team of experienced scientists and engineers, whose intimate knowledge of the resources of NRC and other government departments, linked with their own personal resources and experience, can help in providing solutions to manufacturing and development problems.

The Science and Engineering Student Program (SESP) assists manufacturing firms in solving short-term scientific engineering and technological problems by the "in-plant" use of university or technical college students, supervised by professional personnel.

The Contributions to Laboratory Investigations program (CLIP) provides funds which enable a company lacking a particular kind of expertise to consult with and obtain help from a recognized research institute. The related contributions to small projects (IRAP-M) program is set up for companies with problems in products or processes too great to be handled under CLIP. The contributions to large projects (IRAP-L) is set up to assist companies seriously involved with research projects of two to three years duration or more; a salary support scheme, similar to that in place since 1962, continues to be available.

Another major industrial S & T assistance program initiated by the Council in 1975 is the program for Industry/Laboratory Projects (PILP). The objective of the program is to bring about the application of scientific and engineering knowledge generated in the council's laboratories where significant economic and social benefits to Canada could be foreseen. It is a cooperative program between industry and the council in the identification, development and marketing of technologies to which government scientific or engineering staff make significant contributions. Originally, the program provided support up to 100% of the direct costs of a project, with the Crown owning the patent rights and the companies arranging the licences.

In 1981, a number of significant changes were made in the PILP program. An associated program, Cooperative Projects with Industry (COPI) was formerly set up to achieve the same objectives as PILP in five other participating federal departments. The COPI program has now been consolidated with PILP; overall responsibility for the program has been assigned to the council. The scope of the expanded program in its technology transfer aspects has been extended to cover not only federal government technology, but also that originating from universities and non-profit research centres.

The PILP program operates by either responding to requests made by companies, or by actively seeking out companies as partners in joint ventures aimed at translating advances in technology into commercial products. In these arrangements, the Industrial Development Office gives preference to those companies that can effectively manage the commercialization process and have the appropriate marketing skills.

The council has recently prepared a long-range plan, developed in the context of the current national economic situation. This plan provides a blueprint for the council's role and activities over the next decade and stresses the requirement for an immediate increase in the R & D needed to enable Canadian industry to manufacture and export more high technology products.

Two major projects identified in the plan, those for the construction of a large Vertical Axis Wind Turbine generator (Aeolus) and for the construction of a magnetic confinement device (Tokamak) for research into nuclear fusion, were approved in 1981. The costs of both these projects are being shared equally with the Province of Québec and are part of the council's activities in the energy field. These projects are described in the section on Energy.

The council carries out a broad spectrum of investigations designed primarily to expand scientific knowledge and to explore new topics of interest. It is estimated that approximately $55 million will be spent in this part of the council's work in 1981/82, mostly in the fields of astrophysics and molecular biology.

Improved awareness of the industrial potential of a number of biological processes and techniques collectively known as biotechnology has resulted in increased attention given to this area both in government laboratories and in industry. The National Research Council currently devotes about $9 million and over 225 person-years to intramural R & D in biotechnology and also provides support through its industrial programs for a similar level of activity in Canadian industry. In total the council expects to spend about $120 million on biotechnology over the next 5 years.

The council's effort in biotechnology is centred within the Division of Biological Sciences and the Prairie Regional Laboratory. Projects in the former include the development of vaccines useful in the control of various human and animal diseases and the investigation of biological processes for the production of fuels such as methane from biomass and waste materials. At the Prairie Regional Laboratory in Saskatoon, work is proceeding on plant cell-culture research into the production of useful pharmaceutical agents, fermentation technology and various microbial cell processes.

Because of Canada's vast areas of land and water, harsh climate and scattered population, the energy, food, and transportation fields pose special problems that are currently engaging a considerable part of the council's research capabilities. It is estimated that 1982/83 expenditures in these three areas are $39.7 million, $18.1 million, and $24.5 million, respectively, both for intramural and extramural work.

Several of the council's divisons have the responsibility for maintaining and improving a wide range of national standards. Examples include electrical and engineering standards, involving the investigation of such things as force or acceleration, and standards related to transportation, construction and safety, such as those embodied in the National Building and the National Fire Codes.

International comparisons of primary national standards are an important facet of the standards activity. Such global participation, under the aegis of the Bureau international des poids et mesures, ensures uniform, consistent, physical standards the world over. The standards-related work at the National Research Council has wide-reaching importance outside the laboratory, since it enables the council to provide direct standards services to Canada's industrial sector. For example the council's physicists calibrate nearly all the cameras used for aerial survey photography in Canada and by Canadian companies working abroad.

National facilities for research provided and managed by the council include wind tunnels, optical and radio telescopes, marine engineering and ship laboratories, railway testing equipment, low temperature chambers and rocket and balloon launching ranges. In addition to those facilities directly operated and managed by its staff, the council, through contributions, supports the management of certain major scientific facilities such as TRIUMF, the nuclear physics facility at the University of British Columbia. 1981 saw the opening of a Solar Energy Testing Faculty at the Ontario Research Foundation in Toronto funded by the National Research Council. The council has also expanded its own Acoustic Test Facility, which is used to test delicate communications and other satellites that are subject to the severe vibration and noise associated with launching.

In carrying out its mandate, the National Research Council has long made use of a broad range of committees, and in particular, the Associate Committees. They are established by the council to advise and assist it in dealing with specific concerns of national significance. Not only do these committees assist the council in achieving its objectives but they also provide the Canadian scientific community with an opportunity to influence the course of research and development within the council's laboratories.

In response to the need for a multi-departmental strategy to augment Canada's capability in the field of toxicology, the council formed in 1980 a new Associate Committee on Toxicology. One of the specific problems facing the new committee is the need to expand the training of toxicologists in Canada as well as toxicological research. Initially, the committee will concentrate on collecting information on various aspects of the problem as well as promoting an exchange of information among Canadian toxicologists.

Acting in support of the Associate Committee on Scientific Criteria for Environmental Quality, the council's Environmental Secretariat collates and publishes scientific criteria bearing on the quality of the Canadian environment. As well as providing information and data derived from the scientific literature, the committee's publications also include discussions on the fundamental principles that relate to contaminant-environment interactions in addition to data on the effects of specific contaminants.

In the international sphere, the council continues to represent Canada's scientific and engineering community within the International Council of Scientific Unions and eighteen of its components, as well as in eight international engineering organizations. The council also continues to share with the Canadian Engineering Societies Committee in the activities of the World Federation of Engineering Organizations and the Pan-American Union of Engineering Societies.

The International Energy Agency (IEA) is an important focus for international cooperation in research and development on renewable energy, energy conservation, and nuclear fusion. The council now participates on behalf of Canada in 16 of its projects in cooperation with institutions in other countries.

In recognition of the role of science and technology in addressing problems faced by developing countries of the world, the council has recently established a Science and Technology for Development Office. This office will, in cooperation with the Canadian International Development Agency and the International Development Research Centre, facilitate the application of technological advances arising in the council's and other laboratories to meet the needs of less-developed countries. This will be done through a variety of means such as visits, consultations and the encouragement of appropriate research projects.

Natural Sciences and Engineering Research Council

Program	Science Resources					
	1980/81		1981/82		1982/83	
	S&T	R&D	S&T	R&D	S&T	R&D
	(millions of dollars)					
Scholarships and Grants-in-Aid of Research	159.5*	143.6	197.5*	176.6	221.4*	197.9
Administration	3.3	2.7	4.3	3.4	5.7	4.5
Total	**162.9**	**146.2**	**201.8**	**180.0**	**227.1**	**202.5**

* Includes funds for NATO scholarships ($0.5 million in 1982/83).

The estimated expenditures of $227.1 million to be made in 1982/83 by the Natural Sciences and Engineering Research Council are $25.3 million or 12.5% higher than forecast expenditures in 1981/82 and $64.2 million or 39.4% higher than in 1980/81.

The objective of the program is to promote and support the development and maintenance of research in the natural sciences and engineering and to assist in the provision of highly qualified personnel in these areas. Concomitant sub-objectives are as follows:

- to support excellence in research for the creation of new knowledge in the natural sciences and engineering;
- to promote and support the development of research in selected fields of regional and national importance; and
- to assist in the provision and development of highly qualified personnel.

As with the Medical Research Council, nearly all of the council's grant budget —95%— is used to support research and research training in Canadian universities, and a high priority is given to "free" or discipline-based research for which the university environment is considered to be most suitable.

This university support is discussed more fully in the Extramural-University section. Of the remainder of the 1982/83 budget, an estimated $4.1 million will be spent in support of Canadians undertaking research or research training outside Canada, and an estimated $3.2 million will be spent for support of S & T in Canadian non-profit institutions. The council also intends to provide $4.4 million for industrial undergraduate awards and research fellowships. The council's program is organized into four activities which are described in the following paragraphs.

Peer Adjudicated Grants will involve estimated expenditures of $141.4 million compared to $133.4 million in 1981/82 and $113.8 million in 1980/81. These are grants awarded to individuals on a competitive basis to assist in defraying the operating and equipment expenses of research projects.

Developmental Grants will be awarded up to an estimated $39.7 million compared to $33.2 million in 1981/82 and $24.1 million in 1980/81. A substantial increase in funding will be made to research in areas of national concern through the Strategic Grants program which is included under the Developmental Grants activity—from $21.7 million in 1981/82 to $26.3 million in 1982/83. Expenditures in 1980/81 were $17.8 million. An encouraging response and an improved quality of research proposals has been observed since the introduction of the Strategic Grants Program in 1977. Although it is anticipated that the percentage of funding assigned to this program will remain below 15% of the council's total budget, studies show that many of the best researchers supported through peer-adjudicated grants are carrying out research in areas of national concern. In addition, more than half the applications for support involve group efforts. Areas identified for support through strategic grants are energy, environmental toxicology, oceans, communications and agriculture/food. In addition, an "open" area exists in which researchers can submit proposals for research in any other selected area of national concern. An increase from $2.3 million in 1981/82 to $3.1 million in 1982/83 will also be made in the program of Project Research Applicable to Industry (PRAI), which is a component of the council's Development Grants activity.

Expenditures for the Highly Qualified Manpower Training and Development activity will be an estimated $37.1 million in 1982/83, compared to $28.4 million in 1981/82 and $19.7 million in 1980/81. This activity provides support to undergraduate students, postgraduate students and post-doctoral fellows through bursaries, scholarships and fellowships awarded in national competitions. Highly qualified manpower programs will be expanded to increase the number of awards that will be tenable in industry. This expansion relates to the national goal of increased R & D, by encouraging the training of highly qualified manpower, particularly in areas at the university-industry interface.

In 1980 the council implemented a program of research fellowships, called University Research Fellowships, for temporary, non-tenured faculty research positions. One hundred fellowships were awarded in 1980 and an additional 75 new awards made in 1981/82. An equivalent program in industry, called the Industrial Research Fellowship program, provided 37 new awards in 1980/81 and 75 in 1981/82. These programs are intended to expand career opportunities for a selected number of very promising researchers in the natural sciences and engineering in universities and in industry.

The sub-objectives of the university component of this program are:

- to assist in maintaining the level of the university research and development effort in Canada;

- to assist in maintaining an adequate supply of promising and highly qualified researchers in Canadian universities to help meet the demand for new faculty appointments which is expected to expand rapidly in the early 1990's when the retirement rate of the existing research force increases significantly and when student enrolments start to increase again.

Furthermore, both this program and the corresponding program of Industrial Research Fellowships are expected to encourage closer interaction between researchers in the universities and in industry and increased mobility between these two sectors.

The council contributes up to $26,000 per year towards the salary and fringe benefits of the university research fellows, in addition to providing a research grant. Universities will complete the remuneration if required, provide the fellow with space and basic facilities and defray the indirect costs of research.

Expenditures on National and International Activities will increase from $1.9 million in 1981/82 to $2.6 million in 1982/83. These funds are used to support both national and international conferences, the publication of Canadian scientific journals and to assist Canadian scientific societies.

Statistics Canada

Program	Science Resources					
	1980/81		1981/82		1982/83	
	S&T	R&D*	S&T	R&D	S&T	R&D
	(millions of dollars)					
Program Expenditures	144.1	—	230.0	—	187.2	—

* R&D refers to R&D in the Natural Sciences only.

As the national statistical agency, Statistics Canada has a mandate to collect and publish a wide range of social and economic information. It is also responsible for co-ordinating its activities with those of other producers of official statistics.

Although the original *raison d'être* for the Bureau was to ensure the national census of population and agriculture, it was not until the Statistics Act of 1918 was passed that it became the nation's central statistical agency.

Since then, other statistical activities, once ancillary to the two major censuses, have grown alongside and assumed equal status and significance. In particular, Statistics Canada has the responsibility for producing what are presently regarded as the key policy barometers of the state: the current economic measures of production and trade in all commodities, and indicators such as the unemployment rate and the consumer price index.

Statistics Canada organizes its work under two broad subject matter areas, Economic Statistics and Social Statistics, as well as under a marketing and communications group and various support services.

The agency's science expenditures for 1982/83 are estimated to be $187.2 million, 18.6% lower than in 1981/82, the year of the decennial census, and 30.0% higher than in 1980/81.

Since 1981 was the year of a major national census at Statistics Canada, much of the spotlight in 1982/83 will be on the results of the census count as part of Census 81 in which more than 24 million Canadians were enumerated along with an estimated 340,000 agricultural holdings. As a result, much-needed statistical information will become available for use by all levels of government and by industry, labour unions, academic researchers, ethnic organizations and others. By late 1982, the publication program will commence, and by early 1984 will be available in over 50 different areas. These range from population distributions, trends in the labour force, and the status and retention of mother tongues, to emerging patterns of fertility of women, viewed in terms of such characteristics as education and female participation in the labour force. For the first time, 1981 summary data will also be available through CANSIM—the Statistics Canada machine-readable data base. In addition, users requiring highly-specialized data will be able to request tabulations corresponding to their particular needs.

As is the case every five years, a census of agriculture was also carried out at the same time as the census of population. This census provides data on crop acreage, yield and production estimates, inventories of livestock and poultry as well as assessments of farm income and expenditure accounts. By carrying out the census of agriculture as the same time as the census of population, field staff can be shared and the cost minimized. Nonetheless, farm surveys in general remain complex and, in an effort to reduce the expense of these surveys, Statistics Canada has joined the world of satellite technology.

In an effort to reduce the expense of these surveys, Statistics Canada is starting to employ satellite technology. In 1980, the Agriculture Statistics Division initiated a successful remote sensing project whereby images of the St. John River Valley obtained from a Landsat satellite were used to identify and estimate potato acreage. Since this initial project proved a success, the division expanded its projects to include estimations of canola (rapeseed) fields in northern Alberta and British Columbia. Plan for 1982 involve a pilot project in Prince Edward Island and an expansion of the Alberta project. Ultimately, it is hoped that the remote sensing project will supplement the more traditional and costly ways of surveying crop acreage. At the same time, data collection by satellite significantly reduces the problem of response burden.

Other developments in the area of agricultural statistics include a program to establish an information base on energy use on farms. This program will entail enumeration of 7,000 farms across Canada in July 1982 and will gather data on energy consumption, fuel storage capacities, expenditures and energy conservation practices. The data base, which will be available in the first quarter of 1983, will be used for a wide range of policy initiatives, including "off-oil" and energy conservation projects and the assessments of priorities among energy research and development projects. These data will also contribute to the development and work of a voluntary task force on energy conservation in agriculture.

The largest continuing survey program carried out by Statistics Canada is the monthly Labour Force Survey (LFS) which is conducted through personal and telephone interviews in some 56,000 households across Canada. The survey is designed to provide timely and accurate information on the levels and trends in the composition and characteristics of the Canadian labour force. It is a key economic indicator and is also used in the administration of the Unemployment Insurance program. Since its inception in 1945, the Labour Force Survey has been redesigned after each decennial census. One of the results of the current redesign will be production of supplementary estimates of monthly changes in the labour force. Such estimates will focus on hirings and separations from employment, as well as on multiple transitions over longer periods of time.

However, the Labour Force Survey forms only a part of the labour picture at Statistics Canada. Since there are several other important streams of activity in this area, the agency has set up a central Labour Market Analysis Group to bring the various production and analytical activities into sharper focus. At the same time, the group will be concerned with promoting more effective communication with principal users of labour market statistics, such as the Canadian Employment and Immigration Commission, and Labour Canada.

In 1982, Statistics Canada will also be working on plans to use existing records on family allowances and old age security in order to amplify data on the young and the old. At the same time, work will begin on developing a picture of unemployment in smaller areas. It is expected that by March of 1983 "experimental data" from the 1980 tax year will be available for all provinces, all census divisions or countries and for census tracts in selected cities. Tabulations will be possible in terms of such characteristics as age, sex, marital status, mailing address and source of income.

The agency is placing an increased emphasis on providing data on the changing expenditure patterns of Canadian families. Since World War II, only three such national surveys have taken place — in 1948, 1969 and 1978. However, a regular program of family expenditure surveys (FAMEX) is scheduled to begin in 1982. The FAMEX data will serve a crucial role in providing weights for the Consumer Price Index and will also be used extensively in studies of living costs and levels of living, total taxes and of demand for individual products.

The Survey of Consumer Finances is also undergoing changes since new concepts of money income are now being considered. The new money concepts include refundable tax credits, which have become much more prevalent in recent years. At the same time, the bureau is reviewing its low income poverty indicators with particular attention being given to existing low income cut-offs and potential alternatives.

Recent and current trends indicate that demographic characteristics are changing in Canada. It has been seen that these demographic trends are both unstable and cyclical. At times, there are periods of high fertility;

at times periods of low fertility. These in turn mean high growth rates and low growth rates as well as major shifts in the age structure of the population. In 1982, the agency will complete a new periodical publication highlighting these demographic changes. It will focus on selected facts and issues in the field of population that are likely to be of interest to the general public and in particular to policy makers. One distinctive feature of the publication will be its analysis of the potential socio-economic implications of demographic trends and variations.

Statistics Canada is currently undertaking some re-arrangement of many of its existing programs. On June 1st, 1981 the Canadian Centre of Justice Statistics was established within the agency. The centre is to be the hub of a revitalized national justice statistics system. Its nature is unique. While it works under the responsibility and authority of Statistics Canada, it will be guided by a Justice Information Council composed of federal and provincial deputy ministers as well as the Chief Statistician of Canada. The centre will operate programs in the area of law enforcement, legal aid, corrections, criminal courts, non-criminal courts and juvenile courts and services. In addition, the Centre has been set up to encourage the improvement of existing data-producing systems.

One of the more striking new developments at Statistics Canada is the compilation of the State of the Environment Report for Canada. This report will not only be the first such volume produced, it will also be one of the first national reports to be structured within an ecological framework. The report is being produced in collaboration with the Department of Environment and will be aimed at members of the public who are interested in environmental matters. The information presented will centre on terrestial as well as aquatic ecosystems within the country and, to the extent possible, historical perspectives will be included.

One of the specific responsibilities of the Chief Statistician of Canada is the administration of the Corporation and Labour Unions Returns Act (CALURA) for the Minister of Supply and Services. The purpose of this Act is to facilitate reporting on the extent and effects of foreign ownership and control of Canadian businesses as well as on the association of Canadians with international labour unions. In 1981 Parliament passed major amendments to CALURA providing for the direct collection of financial returns and, for the first time, information on technology transfers to Canadians from abroad. Concomitantly, information on individual corporations will become available to selected government analysts for policy purposes, and membership information about labour unions will be made available to provinces for publication purposes. At the same time, some 96,000 smaller Canadian-owned businesses will be relieved from reporting under the Act.

As a result of these changes the agency has established a new system capable of collecting, processing and analyzing the data at a far faster pace and on an integrated basis. The system also provides a more complete picture of union activity in Canada, especially in terms of its revenues, expenditures, and special funds such as strike and pension funds.

Statistics Canada is also active in the development and setting up of computerised models and data bases as analytical tools for the use of federal and provincial government departments, business, research institutions and academia. Plans in this area include the further development of the long-term simulation model and its components, for the analysis of renewable and non-renewable resource requirements, energy and labour; the representation of technology through the process encyclopedia and process models; an energy data base and the inter-provincial and Canada-U.S. models; all of which will also be used to produce analytical papers on issues of current interest.

Transport Canada

	Science Resources*						Total Resources
	1980/81		1981/82		1982/83		1982/83
Program	S&T	R&D	S&T	R&D	S&T	R&D	
	(millions of dollars)						
Administration	6.1	3.6	9.4	5.6	10.6	6.0	111.6
Marine Transportation	8.5	1.3	8.9	2.8	9.9	8.4	566.4
Air Transportation	2.4	0.3	2.8	0.6	3.2	1.0	646.8
Surface Transportation	0.1	<0.1	0.2	<0.1	0.3	<0.1	902.2
Total	**17.1**	**5.2**	**21.4**	**9.0**	**24.0**	**15.6**	**2,227.0**

* The table sets out science expenditures within each of the four Budgetary Programs of the department. However, these program expenditures do not necessarily correspond on a one to one basis with the total science expenditures supporting the air, marine or surface modes of transportation.

Within total estimated resources of $2,227.0 million for 1982/83, the estimated expenditures of Transport Canada for scientific activities will be $24.0 million, a relatively small 1% of the department's total expenditures. This low proportion reflects the situation in which a major proportion of expenditures are required for the continuing upkeep, operation and expansion of existing mature transportation networks, mainly through the application of existing techniques and acquisition of standardized components. A major new direction in R & D expenditures of $14 million in 1982/83 is included for Arctic Marine R & D and Rail Freight R & D and is discussed more fully in the Major Applications Section on Transportation.

Transport Canada interacts with the transportation networks not only through its support services and regulatory responsibilities for Canadian transportation, but also through the operation of certain elements of the transportation network. Within the department, the Canadian Marine Transportation, Canadian Air Transportation and Canadian Surface Transportation Administrations undertake S & T activities that are in support of their direct program functions. The Research and Development Directorate, part of the Strategic Planning Group within the Administration Program, has a leadership role, being responsible for developing federal and departmental priorities and also coordinating the federal programs in transportation R & D. This is done through its Research Planning and Coordination Branch. This directorate is responsible, through the same Branch, for the development of the department's objectives and strategies, involving the development, coordination and management of R & D in the areas of energy efficiency in transportation, the transportation of energy commodities and liquid fuels. Through its Transportation Development Centre in Montreal, the directorate fulfills its responsibilities for providing S & T support to the other administrations of Transport Canada by providing specific data and conducting research and demonstration projects, and for undertaking S & T projects that both support the department's strategic objectives and are outside the direct program functions of the administrations.

Four modal advisory boards have been created to facilitate integration with industry: the Rail Advisory Committee, the Marine Advisory Board, the Highway Advisory Board, and the Aeronautics Advisory Board. These boards are composed of members predominantly drawn from industry together with representation from the federal government and other Canadian organizations with transportation interests. They formulate research and development programs and recommend projects within the designated transportation modes. Projects proposed by the boards are undertaken on a shared-cost basis between government and industry.

The intramural research and test facilities of Transport Canada are relatively small establishments with budgets totalling about $4.0 million in 1982/83. Consequently most of the R & D is contracted out and much of the subsequent testing and evaluation is carried out using the government-operated elements of the national transport systems.

The majority of Transport Canada's R & D activity for 1982/83 is of an ongoing nature, concerned with marine, air and surface transportation and energy matters. Increased emphasis for three years beginning in 1981/82 has been put on Arctic Marine and Rail Freight R & D.

S & T in marine transportation involves such things as improving the handling capacity of the St. Lawrence Seaway and extending its navigation season. Marine R & D is also undertaken in areas of improved navigation, ice forecasting and iceberg collision avoidance technology; improvements of steel, new hull, propeller and power-plant design required for year round Arctic operation; study of sea ice and ocean conditions in Arctic shipping lanes; improvement of equipment and standards to minimize environmental impacts and to combat spills; fleet systems; communications and control; and, ship safety. Activities in marine S & T also include investigations related to the shipment and handling of bulk coal, grain and iron ore products, improvements in general cargo handling techniques, the modernization of National Harbours Board ports, and the development of proper facilities and techniques for handling liquified natural gas including the necessary guidelines, regulation and standards for its handling.

In the area of air transportation, the S & T activity is undertaken to incorporate new developments into communications, air traffic control methods, navigation aids and airport productivity. Project areas include continuing investigation of new construction techniques, the performance of airport equipment, design and planning of computer simulation techniques, improvement to air traffic control equipment and procedures, continuing development of air traffic control simulators, safety-related projects and environmental (noise and air pollution) projects.

In respect of the surface transportation mode, activities are generally broken down into road and rail S & T. Road S & T activities are undertaken in the areas of: transportation technology for the handicapped; road safety; the effects of fatigue, alcohol and drugs on driver behaviour; vehicle operations and maintenance; the impacts of the changes in road design and traffic operation which may be possible due to car down-sizing; the correlation between estimates based on laboratory tests of fuel consumption and the actual road experience; the development of pre-driver education curricula: basic research into the crash avoidance process; active stability for coupled vehicles; development of radar range and relative velocity transducers; vehicle noise measurement and urban transportation. Rail S & T activity is undertaken in areas of: standards for high speed operations; railway crossing protection; transportation for handicapped passengers; and energy allocation priorities for passenger rail transportation R & D to increase railway efficiency and productivity. Other efforts are in: equipment design; noise reduction in urban areas; track/train dynamics; signalling, communications and control; and railway systems. New work is being initiated to further computerize railway control operations, to develop lighter, more fuel-efficient engines, to develop alternative fuels for railway operations, including electrification and to design steerable rail car trucks, improved braking systems, and multi-modal terminals. The department also cooperates with Via Rail, Canadian National and Canadian Pacific railways in ensuring that S & T in support of their operations is carried out.

Transport Canada is also involved in a number of other S & T programs such as transmodal safety, energy efficiency in transportation, liquid fuels and transportation of energy commodities as well as in the transportation, storage and transfer of hazardous commodities.

6. Regional Expenditures and Activities

The most recent fiscal year for which regional data on federal science expenditures are available is 1979/80 (Table 6.2). In 1979/80 Statistics Canada estimates that a total of $1,378 million was spent by the federal government across Canada on activities in the natural sciences (this total excludes about $35 million spent in the foreign sector and about $81 million of scientific expenditures whose allocation could not be specified on a regional basis). Of the above total, $426 million was spent in the National Capital Region (NCR), $326 million in the Western provinces, $315 million in Ontario (excluding Ottawa), $175 million in Quebec (excluding Hull), and $136 million in the Atlantic provinces.

Total intramural expenditures in natural sciences were $886 million, with $385 million of this spent in the NCR. The largest intramural expenditures were those of the National Research Council (NRC), which spent $122 million in the NCR. The NRC made 88% of its total intramural expenditures in the National Capital Region, followed by those of the Departments of Energy, Mines and Resources (EMR) with 81% and Agriculture (AGR) with 29%. Other departments such as Environment (ENV) and Fisheries and Oceans (F & O) performed only 10% and 5% respectively of their intramural activities in the NCR.

Federal science expenditures in Canadian industry amounted to $228 million, of which $119 million was spent in Ontario (including Ottawa), $67 million in Quebec (including Hull), $33 million in the Western provinces and $9 million in the Atlantic provinces.

Federal science expenditures for activities in natural sciences in Canadian universities totalled $214 million in 1979/80. Of this, $82 million was spent in Ontario (including Ottawa), $50 million in Quebec (including Hull), $66 million in the Western provinces and $15 million in the Atlantic provinces.

Federal scientific establishments outside the National Capital Region accounted for $501 million of the $886 million spent in 1979/80 on intramural activities in the natural sciences. Some of the more prominent federal regional establishments are described below.

Atomic Energy of Canada Limited (AECL) maintains Canada's largest nuclear centre, the Chalk River Nuclear Laboratories (CRNL), at Chalk River, Ontario. High priority is given at CRNL to applied research and development in support of the Canadian nuclear power program and includes research on fuel and fuel channels, safety, reactor-waste management, reactor control and instrumentation, and heavy water.

Atomic Energy of Canada Limited also has a second nuclear research centre, the Whiteshell Nuclear Research Establishment (WNRE), located at Pinawa, Manitoba, 100 km northeast of Winnipeg, on the Winnipeg River. Research at the Pinawa establishment is primarily concerned with radioactive waste management and nuclear-reactor safety, with significant effort devoted to health and environmental effects of radiation, chemistry, materials science, and research on advanced fuel cycles employing thorium.

The Department of Energy, Mines and Resources has established the Pacific and Atlantic Geoscience Centres at Patricia Bay, B.C., and Dartmouth, N.S. These centres perform geoscience studies and surveys of the coastal regions, the continental slope and the floor of Canada's oceans. The department also owns the Institute of Sedimentary and Petroleum Geology in Calgary which studies the sedimentary basins of Western and Arctic Canada. In Vancouver the Cordilleran Geology Division is concerned with the composition, structure and geological development of the Cordillera. The Western Research Laboratory, housed in the Alberta Research Council of Edmonton, performs research in carbonization, coal beneficiation, cleaning of process

Table 6.1

Natural Science Expenditures by Region, 1978-79

Region	AGR	EMR	AECL	ENV	NRC	DND	ITC	MRC, NSERC	Other	TOTAL
					(millions of dollars)					
Total All Sectors	**123.0**	**124.2**	**96.5**	**319.2**	**194.6**	**80.6**	**59.4**	**171.3**	**172.9**	**1,341.7**
Atlantic	13.5	5.4	0.4	80.4	6.5	7.9	0.4	11.0	6.2	131.7
Quebec—excl. Hull	10.9	3.0	8.7	21.7	6.8	25.0	25.3	42.6	22.7	166.7
Ontario—excl. Ottawa	11.7	4.8	61.8	97.2	43.0	15.0	22.3	60.7	15.3	332.1
Prairies	37.7	22.0	22.5	40.0	9.4	6.5	2.6	28.6	7.7	177.1
British Columbia	9.1	4.3	–	50.0	14.1	6.1	1.9	18.4	6.1	110.1
National Capital Region	40.1	84.6	3.0	29.9	114.8	20.0	7.0	10.0	114.8	424.0
Intramural Total	**117.7**	**93.3**	**80.2**	**280.8**	**127.7**	**64.7**	**3.7**	**3.5**	**124.4**	**896.1**
Atlantic	13.1	4.3	–	67.6	4.0	7.1	–	–	0.6	96.7
Quebec—excl. Hull	9.7	–	–	17.9	1.0	21.4	–	–	14.1	64.1
Ontario—excl. Ottawa	10.4	0.8	55.5	88.5	1.7	7.8	–	–	1.9	166.7
Prairies	36.1	7.7	22.0	37.3	6.4	5.9	–	–	0.6	116.1
British Columbia	8.6	2.3	–	40.9	3.3	5.3	–	–	1.2	61.6
National Capital Region	39.8	78.2	2.7	28.6	111.3	17.1	3.7	3.5	106.0	390.8
Industry Total	**1.4**	**14.2**	**15.1**	**24.1**	**55.6**	**13.6**	**54.3**	**1.6**	**25.3**	**205.2**
Atlantic	0.1	0.5	–	10.9	2.0	0.7	0.2	0.1	1.2	15.7
Quebec—excl. Hull	0.3	1.3	8.6	2.0	5.4	2.8	25.2	0.3	3.9	49.9
Ontario—excl. Ottawa	0.5	2.7	5.9	4.4	40.7	6.3	21.9	0.8	7.6	90.7
Prairies	0.3	2.2	0.3	1.4	2.4	0.4	1.9	0.1	3.5	12.6
British Columbia	–	1.5	–	4.5	1.8	0.6	1.9	0.2	2.1	12.5
National Capital Region	0.2	6.0	0.2	0.9	3.3	2.8	3.3	0.1	7.0	23.8
University Total	**2.7**	**2.8**	**0.8**	**3.6**	**9.5**	**2.1**	**0.6**	**165.1**	**14.3**	**201.6**
Atlantic	0.1	0.3	–	0.4	0.1	0.1	–	10.8	1.9	13.8
Quebec—excl. Hull	0.5	0.4	0.1	0.7	0.1	0.7	–	42.1	3.2	47.8
Ontario—excl. Ottawa	0.7	0.8	0.4	1.5	0.3	0.8	0.5	59.5	3.6	68.1
Prairies	1.0	0.6	0.1	0.5	0.1	0.2	0.1	28.5	2.7	33.8
British Columbia	0.2	0.5	0.1	0.5	8.8	0.2	–	18.2	2.2	30.7
National Capital Region	0.1	0.2	–	0.1	0.2	0.1	–	6.1	0.5	7.3
Others Total	**1.2**	**13.9**	**0.4**	**10.7**	**1.8**	**0.2**	**0.8**	**1.1**	**8.9**	**39.0**
Atlantic	0.1	0.3	0.4	1.5	0.3	0.1	0.2	0.1	2.5	5.5
Quebec—excl. Hull	0.3	1.4	–	1.0	0.4	–	–	0.3	1.5	4.9
Ontario—excl. Ottawa	0.1	0.5	–	2.9	0.4	0.1	–	0.5	2.2	6.6
Prairies	0.3	11.5	–	0.8	0.5	–	0.6	–	0.9	14.6
British Columbia	0.3	0.1	–	4.1	0.2	–	–	–	0.6	5.3
National Capital Region	0.1	0.2	–	0.3	–	–	–	0.3	1.3	2.1

Source: Science Statistics Centre, January 1982.

Table 6.2

Natural Science Expenditures by Region, 1979-80

Region	AGR	EMR	AECL	ENV	F&O*	NRC	DND	ITC	MRC, NSERC	Other	TOTAL
					(millions of dollars)						
Total All Sectors	**140.9**	**132.8**	**90.0**	**184.7**	**113.1**	**199.1**	**86.9**	**81.5**	**184.9**	**163.7**	**1,377.6**
Atlantic	25.6	6.1	0.4	14.9	57.9	6.3	7.7	0.8	12.7	3.8	136.2
Quebec—excl. Hull	11.9	3.2	9.6	15.3	2.1	10.0	27.1	36.8	43.6	15.2	174.8
Ontario—excl. Ottawa	12.7	6.0	53.5	72.4	9.6	30.2	18.5	25.7	68.3	17.9	314.8
Prairies	41.4	38.2	24.0	34.5	5.3	9.2	7.6	3.7	30.7	5.3	199.9
British Columbia	9.8	4.0	0.1	29.0	33.0	16.8	5.6	3.7	19.2	4.5	125.7
National Capital Region	39.5	75.3	2.4	18.6	5.2	126.6	20.4	10.8	10.4	117.0	426.2
Intramural Total	**131.9**	**86.9**	**68.6**	**168.0**	**103.1**	**138.3**	**63.8**	**6.4**	**3.7**	**115.6**	**886.3**
Atlantic	24.4	4.6	–	13.7	54.2	4.1	7.0	–	–	0.4	108.4
Quebec—excl. Hull	10.1	–	–	12.6	1.9	1.1	22.1	–	–	6.3	54.1
Ontario—excl. Ottawa	11.0	0.7	43.5	69.6	8.7	1.4	7.7	–	–	4.5	147.1
Prairies	38.6	8.0	23.1	32.9	5.2	5.9	6.7	–	–	0.7	121.1
British Columbia	8.9	2.9	–	22.0	27.9	3.7	4.5	–	–	0.7	70.6
National Capital Region	38.9	70.7	2.0	17.2	5.2	122.1	15.8	6.4	3.7	103.0	385.0
Industry Total	**2.2**	**13.9**	**19.7**	**12.6**	**6.2**	**47.6**	**20.1**	**73.6**	**1.3**	**31.1**	**228.3**
Atlantic	0.2	1.1	0.1	0.8	2.7	1.8	0.5	0.7	0.1	1.0	9.0
Quebec—excl. Hull	0.5	1.3	9.4	1.9	0.1	8.6	4.0	36.5	0.3	4.5	67.1
Ontario—excl. Ottawa	0.6	3.9	9.3	1.6	0.5	27.5	9.8	25.1	0.6	8.8	87.7
Prairies	0.5	2.4	0.6	0.9	–	2.7	0.7	3.2	0.1	1.9	13.0
British Columbia	0.1	0.9	–	6.3	2.9	3.0	0.6	3.7	0.1	2.3	19.9
National Capital Region	0.3	4.3	0.3	1.1	–	4.0	4.5	4.4	0.1	12.6	31.6
University Total	**3.5**	**2.6**	**1.5**	**2.0**	**0.8**	**11.3**	**2.7**	**1.1**	**178.8**	**10.1**	**214.4**
Atlantic	0.3	0.3	0.1	0.2	0.3	0.1	–	–	12.5	1.3	15.1
Quebec—excl. Hull	0.8	0.5	0.2	0.6	0.1	0.2	1.0	0.3	43.1	3.3	50.1
Ontario—excl. Ottawa	0.9	0.9	0.7	0.7	0.2	0.7	0.9	0.6	67.2	2.5	75.3
Prairies	1.1	0.5	0.3	0.2	–	0.2	0.2	0.2	30.6	1.9	35.2
British Columbia	0.3	0.2	0.1	0.3	0.2	9.8	0.5	–	19.1	0.7	31.2
National Capital Region	0.1	0.2	0.1	–	–	0.3	0.1	–	6.3	0.4	7.5
Others Total	**3.3**	**29.4**	**0.2**	**2.1**	**3.0**	**1.9**	**0.3**	**0.4**	**1.1**	**6.9**	**48.6**
Atlantic	0.7	0.1	0.2	0.2	0.7	0.3	0.2	0.1	0.1	1.1	3.7
Quebec—excl. Hull	0.5	1.4	–	0.2	–	0.1	–	–	0.2	1.1	3.5
Ontario—excl. Ottawa	0.2	0.5	–	0.5	0.2	0.6	0.1	–	0.5	2.1	4.7
Prairies	1.2	27.3	–	0.5	0.1	0.4	–	0.3	–	0.8	30.6
British Columbia	0.5	–	–	0.4	2.0	0.3	–	–	–	0.8	4.0
National Capital Region	0.2	0.1	–	0.3	–	0.2	–	–	0.3	1.0	2.1

Source: Science Statistics Centre, January 1982.

* The Department of Fisheries and Oceans was established as a separate department on 2 April 1979; prior data are included in those of the Department of the Environment.

water and fine particle chemistry. The department recently opened a new laboratory in Cape Breton to concentrate on health and safety in coal mines. Other mining laboratories are located at Calgary and at Elliot Lake, Ontario.

Under the aegis of the Department of the Environment, the Canadian Forestry Service has a number of research laboratories outside the National Capital Region. A national forestry institute located at Sault Ste. Marie, Ontario specializes in work on the eradication, control and management of forest pests such as harmful insects, fungi and diseases. A second institute, at Petawawa, Ontario, performs research on silviculture and tree genetics, forest fires, and forest management techniques and practices. In addition to these national institutes, there are six regional centres which carry out R & D designed to apply the general knowledge developed by universities and the national forestry institutes, and to adapt it when necessary to the specific needs of local forest industries. These centres are located in Victoria, Edmonton, Sault Ste. Marie, Quebec City, Fredericton and St. John's.

The Department of the Environment also operates the Canada Centre for Inland Waters at Burlington, Ontario—housing hydrographers, marine scientists and engineers who study the aquatic environments found in Canada's lakes, rivers, coastal waters and oceans.

The Department maintains the Prairie Migratory Bird Research Centre located in Saskatoon which undertakes research on population dynamics and conducts studies on wildlife habitat. The Wildlife Service also has five interpretation centres at points across Canada. The Headquarters of the Atmospheric Environment Service at Downsview, Ontario houses the Canadian Climate Centre, the Satellite Data Laboratory and the Atmospheric Research Directorate which looks into such problems as acid rain and air pollution. The Canadian Meteorological Centre is located in Montreal and is responsible for numerical aspects of weather prediction.

The Department of the Fisheries and Oceans has two large regional establishments—the Bedford Institute of Oceanography at Dartmouth, N.S., and the Institute of Ocean Sciences, at Patricia Bay, B.C. These institutions, along with other smaller specialized laboratories in the various regions of Canada, perform research and related scientific activities in the areas of fisheries management, physical and chemical oceanography, aquaculture, hydrography, water quality monitoring and management, hydrology and hydraulics, and develop and demonstrate innovative and cost-effective technology for the control of water pollution.

Agriculture Canada (AGR) has 52 research establishments of varying sizes and degrees of specialization, located from coast to coast. The research programs are aimed at alleviating current and anticipated agricultural problems in the many soil and climatic zones of Canada. Each research establishment is specifically designed to serve the agricultural needs of the area in which it is located; many of these establishments also conduct research on agricultural problems of national concern.

The Research Branch of the Department of Agriculture has been organized into five regions. The Atlantic Region comprises four research stations and the region's agricultural activity is chiefly based on forage crops, potatoes and fruit crops. The Quebec Region has three research stations. Southwestern Quebec is richly endowed with organic soils and is the province's chief vegetable-growing area. Researchers at Saint Jean, Que., are hoping to reduce the rate of subsidence of the organic soils. The research stations in Ontario conduct research in most major crops. The Ottawa Research Station serves Eastern and Northern Ontario. The Harrow Research Station conducts research in tree fruits, field and greenhouse vegetables and several field crops. The Delhi Research Station specializes in tobacco. The Western region consists of 15 research stations that serve the agricultural community throughout the Prairie provinces and British Columbia. Beef cattle research is conducted in seven of the 15 stations in the West and includes studies on breeding, nutrition, forage utilization and management. Horticulture research is conducted at seven stations. There are also six national research institutes located in Ottawa conducting basic and applied research in various problem areas affecting agriculture and food.

In addition to the Defence Research Establishment Ottawa, the Department of National Defence (DND) has five research establishments outside the National Capital Region. Those in Halifax and Esquimalt (Defence Research Establishments Atlantic and Pacific respectively) concentrate mainly on defence research oriented toward naval matters, including undersea warfare. The Defence Research Establishment Valcartier, near Quebec City, undertakes R & D projects mainly on armaments, but has diversified in recent years into electro-optics, tactical data systems and laser research. It is credited with inventing the world's first atmospheric pressure gas laser. The Defence Research Establishment Suffield near Medicine Hat, Alberta, develops and tests counter-measures against chemical and biological agents, has undertaken major shock and blast trials, and has diversified into research on vehicle mobility, military engineering and hazardous waste disposal. The Defence and Civil Institute of Environmental Medicine in Toronto conducts research on human protection and performance in adverse environments. Its programs include deep diving research, human engineering and the man-machine interface in aircraft and vehicles.

The National Research Council has established five regional laboratories. Three of these laboratories have been in existence for some years:

- the Atlantic Regional Laboratory, on the campus of Dalhousie University, Halifax, Nova Scotia;
- the Prairie Regional Laboratory, on the campus of the University of Saskatchewan, Saskatoon, Saskatchewan; and,
- the Mechanical Engineering Western Laboratory, at Vancouver, British Columbia.

Two new laboratories are in the process of being established:

- The Arctic Vessel and Marine Research Institute, to be located on the campus of Memorial University, St. John's, Newfoundland; and,
- The Industrial Materials Research Institute (L'Institut de génie des matériaux) in the South Shore region near Montreal, Quebec.

The Atlantic Regional Laboratory was established in 1952 to complement and assist other research facilities in the area. Its basic policy has been to engage in fundamental, long-term research in support of resource development in the maritime provinces and it has three main thrusts: marine plant studies, microbiology and high-temperature chemistry.

The Prairie Regional Laboratory's program is agriculturally-oriented with a major theme of plant science, based on long-term fundamental studies of the physiology of plants and micro-organisms, and of the chemistry of their natural products. Projects are selected which will expand the fundamental knowledge base while contributing to problems of the prairie region. An earlier emphasis on utilization of agricultural waste and surpluses has led to activity in support of introducing alternative crops in place of grain production. The Mechanical Engineering Western Laboratory located in Vancouver is mainly concerned with conducting R & D in response to industrial needs. Its program concentrates on three main areas: tribology, special instrumentation and numerically-controlled machining processes.

Construction of a building and facilities for the Arctic Vessel and Marine Research Institute began in 1981 and completion is expected during 1984/85, at a currently-estimated cost of approximately $47 million. The institute's program will be similar in content to that of the council's Marine Dynamics and Ship Laboratory in Ottawa, where studies of the characteristics of marine models enables scientists to predict and evaluate the performance of full-scale structures and vessels. This new facility will extend Canadian capability to develop marine technology for operating in ice-covered and ice-laden waters. Included in the facilities will be an ice towing tank 80 metres long by 12 metres wide and 3 metres deep, with towing carriage, wave-making equipment, under-water closed circuit television and refrigeration.

Considerable progress has been made in establishing the Industrial Materials Research Institute. A permanent site has been purchased at Boucherville on the South Shore region near Montreal and completion of a permanent building is expected in mid-1983 at a currently-estimated cost of $22 million. In the meantime staff is being lodged in rented office space in Longueil and in temporary laboratory facilities installed in a rented warehouse near Boucherville.

When fully operational in 1983/84, the institute will have a total staff of about 210, 120 of whom will be temporary and permanent council employees, and the other 90, researchers from industry and universities. A significant portion of the program will be contracted-out. French will be the working language, in recognition both of the milieu and the emphasis on aid to Quebec industry.

During the transitional period, the institute has been receiving an excellent response from potential industrial partners and about 70 projects have been identified. About half of these are short-term projects, which the institute has combined into a useful short-term industrial program of technology transfer and direct assistance.

Appendix I

Federal S&T Expenditure Data

This section provides an overview of the scope and limitations of the science expenditure data used in this report, as well as some details about the collection process. It also defines the various categories of science expenditure data referred to in the text.

Collection is undertaken to gather essential data describing the recent, the current, and the proposed state of the federal resources allocated to scientific activities. Data on the scientific expenditures in more than 100 programs of some 60 federal departments and agencies, covering three financial years, are collected annually by means of Science Addenda to the Main Estimates of departments. The focus of attention is on the upcoming financial year; also collected are historical data for the past year, as well as confirming data in respect of expenditures in the current financial year.

The collection of such data from the financial administrations of departments and agencies is carried forward by the Ministry of State for Science and Technology (MOSST), in cooperation with the Treasury Board Secretariat and the Science Statistics Centre of Statistics Canada. Statistics Canada maintains the historical expenditure series in the natural and human (social) sciences; historical, regional and other science statistics tabulations are available from that source. Also involved is the Interdepartmental Committee on Scientific Expenditures which is the formal mechanism for liaison and discussion of broad problems arising in the gathering of federal science expenditure data.

Expenditure Breakdowns

When science expenditure data are collected, departments and agencies are asked for information respecting their various budgetary programs, as defined in the Estimates to be voted upon. A program, or some given activity within it, may be scientific in whole or only in part. It is just the expenditures on scientific components of a program or its activities which are reported in the science expenditures survey. Within each budgetary program separate reports are requested for the *natural* and the *human* sciences activities which may occur within it.

Within the major fields of science expenditure, additional breakdowns are made under the major headings of *Research and Development* (R & D) and *Related Scientific Activities* (RSA) which are themselves further sub-divided better to indicate the "how" and "what" of a department's scientific effort. Expenditures on the broad categories of scientific activity (R & D, RSA) are also sub-divided into "current" and "capital" expenditures for such things as new laboratory buildings or major facilities. Furthermore expenditures are additionally sub-divided to show the sector in which the activity is performed (e.g., federal intramural (or in-house), industry or universities).

The industry sector performance data are further supplemented and expanded upon in the course of the "Regional" Survey undertaken by the Science Statistics Centre, in order to identify both the geographic (regional) distribution of R&D contracts to industry as well as the regional distribution of federal science expenditures.

The "why" of departmental scientific activities is broadly addressed in the Main Estimates Science Agenda by asking departments to identify areas of expenditure application (e.g., oceans, energy), and whether intramurally or extramurally performed. Furthermore, the human resources allocated to scientific activities are summarized in terms of the personnel categories (executive, scientific and professional, etc.) and the principal foci of their efforts (e.g., R&D, RSA, administration of extramural programs) are also identified.

Comparability

Readers should note that the data presented in the report correspond to the *budgetary expenditures by program* presented in Main Estimates for the approval of Parliament. In particular, the data do *not* include "*non-program costs*", i.e., the costs of services and accommodation costs provided without charge by other departments, and the portion of administrative costs attributable to scientific activities which arise in a separate administration program. The exclusion of non-program costs enables one to compare directly expenditures on scientific and technological (S&T) activities with other types of program expenditures in the federal sector. Readers should also note that the data are based on gross expenditures within the program, not on "voted" estimates. That is, the data include S&T expenditures funded from revenues and receipts credited to the vote and from funds transferred to the program from other programs and/or departments.

There are circumstances in which it is usual to compare total costs of activities, including overheads and proportional shares of common services. If one's purpose is to compare the magnitude of federal S&T activities with those in other sectors or other countries, then it is the custom to consider total costs. In this context the sum of total program expenditures plus non-program costs would represent the "total" cost of the scientific and technological effort as defined here. With appropriate caution, such data may be compared with those for industry where all costs, direct and indirect, are reported. For comparisons of this kind, *Statistics Canada* publishes *The Annual Review of Science Statistics* (Cat. No. 13-212) and its *Service Bulletins* (Cat. No. 13-003). The federal intramural expenditures reported in those publications will thus appear greater than in this publication by the amount of non-program costs. The federal extramural expenditures are not affected and will appear the same in both sets of publications.

Terminology

Many of the terms employed in the description of scientific expenditures have quite specific meanings. Activities involving *science and technology* (S&T) are understood to mean those involving the generation, dissemination and initial application of new scientific knowledge and related technology.

Such activities may involve the fields of *natural sciences* or the *human sciences*. The *natural sciences* consist of disciplines concerned with understanding, exploring, developing or utilizing the natural world. Included are the engineering, mathematical, life and physical sciences.

The term *human sciences* is synonymous with "social sciences and humanities": it includes the disciplines involving the study of human actions and conditions as well as the social, economic and institutional mechanisms affecting humans. The human sciences include such disciplines as anthropology, business administration and commerce, communications, criminology, demography, economics, geography, history, languages, literature and linguistics, law, library science, philosophy, political science, psychology, religious studies, social work, sociology, and urban and regional studies.

The two main categories of S&T activity are research and experimental development (R&D) and related scientific activities (RSA). R&D consists of creative work undertaken on a systematic basis to increase the stock of scientific and technical knowledge or to discover new applications for existing knowledge. RSA generally complement and extend R&D. In the natural sciences, for example, the RSA group includes such things as scientific data collection, scientific information services, testing and standardization, feasibility studies, education support and museum services.

Some other terms with specific meanings in this publication are:

a) performer or funder—the former refers to the organization or sector conducting S&T activities, the latter to the organization or sector which provides, or has the responsibility for budgeting for the required funds;

b) contracts, grants or contributions—*contracts* are legal undertakings between two or more parties for the conduct of S&T activities and the provision of the results of those activities according to an agreed schedule and cost. For most departments, the Department of Supply and Services acts as the contract manager, with the other department providing the scientific or engineering manager. A *contribution* requires an arrangement between the government and the recipient identifying the terms and conditions governing the payment of funds to the recipient. The payments are conditional on performance or achievement and the recipient's use of the funds is subject to audit. A *grant* is an unconditional payment by the government to a recipient; the government does not necessarily recieve any goods or services as a direct result.

c) *person years*—a measure of the time actually devoted to the conduct of scientific activities. An employee who is engaged in scientific activities for half a year has, for example, a person-year equivalence of 0.5.

Detailed definitions of terms used in scientific expenditure surveys are presented in the sister publication "Federal Science Expenditures and Personnel 1982/83".

Appendix II

Science Expenditures by Vote for Major Funders

	Vote	Gross Science Resources						Total Voted Estimates 1982/83	
		1980/81		1981/82		1982/83			
		$M	PY	$M	PY	$M	PY	$M	PY
Agriculture—Total		**152.4**	**4,018**	**168.5**	**4,179**	**196.1**	**4,026**	**953.0**	**10,683**
Administration—Total	1 & S	4.2	112	4.8	117	5.1	122	44.2	917
Agri-Food Development—Total		140.7	3,686	155.1	3,821	178.8	3,663	687.6	4,614
Operating	5 & S	125.5		141.9		157.9		201.9	
Grants & Contributions	15 & S	4.8		3.3		2.0		466.3	
Capital	10	10.4		10.0		18.9		19.4	
Agri-Food Regulation and Inspection—Total		4.6	136	5.1	149	8.0	149	185.5	4,283
Operating	20 & S	4.4		5.0		6.1		171.2	
Grants & Contributions	30	—		—		—		5.8	
Capital	25	0.2		0.1		1.9		8.6	
Canadian Grain Commission—Total		2.9	84	3.5	92	4.2	92	35.7	869
Operating	35 & S	2.8		3.4		3.8		34.3	
Grants & Contributions	35	<0.1		<0.1		<0.1		<0.1	
Capital	35	0.1		0.1		0.4		1.4	
Communications—Total		**66.0**	**670**	**82.3**	**689**	**67.5**	**733**	**363.4**	**2,130**
Communications—Total		65.3	660	81.3	679	66.7	724	125.6	2,050
Operating	1 & S	38.9		50.1		47.2		101.4	
Grants & Contributions	5	11.0		15.7		2.9		4.8	
Capital	5	15.4		15.5		16.6		19.3	
Arts and Culture—Total		0.7	10	1.0	10	0.8	9	237.8	80
Operating	10, 20 & S	0.7		1.0		0.8		225.8	
Grants & Contributions	20	—		—		—		12.0	
Capital	15	—		—		—		<0.1	
National Library—Total		**17.2**	**517**	**21.6**	**517**	**25.8**	**526**	**25.8**	**526**
Operating	65 & S	16.8		21.2		25.8		25.7	
Grants & Contributions	65	<0.1		0.1		<0.1		<0.1	
Capital	65	0.4		0.4		0.1		0.1	
National Museums—Total		**54.0**	**1,006**	**58.7**	**975**	**61.8**	**1000**	**61.8**	**1000**
Operating	70 & S	43.9		48.8		52.2		52.2	
Grants & Contributions	75	9.3		9.4		8.9		8.9	
Capital	70	0.8		0.5		0.8		0.8	

Appendix II Science Expenditures by Vote for Major Funders (continued)

		Gross Science Resources						Total Voted Estimates 1982/83	
	Vote	1980/81 $M	1980/81 PY	1981/82 $M	1981/82 PY	1982/83 $M	1982/83 PY	$M	PY
Social Sciences & Humanities Research Council—Total		**42.4**	**105**	**46.6**	**105**	**56.7**	**105**	**56.7**	**105**
Operating	85 & S	3.9		4.4		5.3		5.3	
Grants & Contributions	90	38.4		42.2		51.3		51.3	
Capital	85	<0.1		<0.1		<0.1		<0.1	
Energy, Mines & Resources—Total		**179.1**	**2,484**	**229.7**	**2,467**	**280.5**	**2,592**	**4,051.1**	**4,660**
Administration	1 & S	—	—	—	—	—	—	19.3	438
Energy—Total		48.5	58	70.3	65	81.6	96	3,809.2	1139
Operating	5 & S	3.6		7.9		13.5		118.5	
Grants & Contributions	10	44.9		62.4		68.1		3,689.8	
Capital	5	—		—		—		0.9	
Minerals & Earth Sciences—Total		130.5	2,426	159.4	2,402	198.9	2,496	222.6	3,083
Operating	40 & S	118.2		141.2		163.6		187.2	
Grants & Contributions	40	4.3		3.5		4.2		4.2	
Capital	45	8.1		14.6		31.1		31.1	
Atomic Energy of Canada Ltd.—Total		**96.8**	**2,394**	**114.2**	**2,512**	**132.4**	**2,615**	**317.6**	**8,439**
Operating	55 & S	89.2		101.0		114.7		283.2	
Grants & Contributions	55	—		—		—		—	
Capital	60	7.6		13.2		17.7		34.4	
Environment—Total		**247.1**	**4,915**	**279.0**	**4,924**	**334.1**	**4,936**	**726.8**	**11,623**
Administration—Total		1.8	51	1.9	47	2.1	47	39.7	841
Operating	1 & S	1.5		1.8		1.9		39.5	
Grants & Contributions	1	—		—		—		0.2	
Capital	1	—		—		—		0.1	
Environmental Services—Total		232.7	4,670	263.2	4,681	316.6	4,693	409.1	5,724
Operating	5 & S	189.5		206.9		239.8		324.9	
Grants & Contributions	15	6.3		8.4		9.2		51.3	
Capital	10	11.4		19.4		22.2		32.9	
Atmospheric Environment—Total		115.8	2,335	134.1	2,335	164.8	2,342		
Operating		107.3		123.5		144.6			
Grants & Contributions		1.0		1.0		1.0			
Capital		7.5		9.6		19.2			
Environmental Protection—Total		8.8	162	8.2	161	10.0	171		
Operating		7.9		7.7		9.4			
Grants & Contributions		—		—		—			
Capital		0.8		0.5		0.6			
Environmental Conservation—Total		57.8	1,148	62.6	1,148	72.4	1,148		
Operating		48.6		53.0		62.5			
Grants & Contributions		4.2		4.6		5.0			
Capital		5.0		5.0		5.0			
Canadian Forestry Service—Total		50.3	1,025	58.3	1,037	69.4	1,032		
Operating		42.5		50.6		61.4			
Grants & Contributions		4.0		4.1		4.1			
Capital		3.7		3.7		3.9			

Appendix II Science Expenditures by Vote for Major Funders (continued)

	Vote	Gross Science Resources						Total Voted Estimates 1982/83	
		1980/81		1981/82		1982/83			
		$M	PY	$M	PY	$M	PY	$M	PY
Parks Canada—Total		12.6	194	13.9	196	15.4	196	277.9	5,058
Operating	20 & S	7.8		8.6		9.6		176.2	
Grants & Contributions	20	—		—		—		0.7	
Capital	25	4.8		5.3		5.8		101.0	
Canadian International Development Agency—Total		**36.5**	**57**	**40.4**	**57**	**45.0**	**57**	**943.7**	**986**
Operating	30 & S	2.2		2.4		2.8		47.6	
Grants & Contributions	35	34.3		38.0		42.2		896.0	
Capital	30	—		—		—		0.1	
International Development Research Centre—Total		**39.8**	**218**	**46.0**	**239**	**56.6**	**264**	**59.2**	**389**
Intramural	45	12.1		14.2		17.4			
Extramural	45	27.7		31.9		39.2			
Fisheries & Oceans—Total		**116.4**	**2,143**	**130.0**	**2,273**	**145.8**	**2,390**	**452.1**	**5,819**
Operating	1 & S	101.0		119.8		134.0		365.1	
Grants & Contributions	10	0.6		0.5		0.5		10.4	
Capital	5	14.8		9.7		11.3		76.7	
Industry, Trade & Commerce—Total		**97.5**	**167**	**143.5**	**167**	**173.3**	**181**	**766.6**	**2,705**
Trade-Industrial—Total		95.9	160	142.0	160	171.9	175	576.7	2,356
Operating	1 & S	6.2		7.0		8.5		168.0	
Grants & Contributions	10	89.7		135.0		163.4		407.9	
Capital	1	—		—		—		0.8	
Tourism—Total		0.3	4	0.4	4	0.4	4	43.2	291
Operating	45 & S	0.3		0.4		0.4		40.8	
Grants & Contributions	45	—		—		—		2.3	
Capital	45	—		—		—		<0.1	
Grains & Oilseeds—Total		1.2	3	1.1	3	1.1	2	146.8	58
Operating	50 & S	0.1		0.1		0.1		3.3	
Grants & Contributions	55	1.2		1.1		1.0		143.4	
Capital	50	—		—		—		—	
National Defence—Total		**102.6**	**1,870**	**112.0**	**1,877**	**139.6**	**1,878**	**7,041.3**	**118,014**
Operating	1 & S	85.4		100.5		127.1		5,145.0	
Grants & Contributions	10	—		—		—		385.7	
Capital	5	16.8		11.2		11.9		1,510.6	
National Health & Welfare—Total		**63.8**	**1,334**	**72.6**	**1,398**	**80.9**	**1,437**	**19,331.8**	**9,352**
Administration—Total		6.0	108	8.1	121	9.0	128	38.5	838
Operating	1 & S	4.3		5.8		6.7		35.8	
Grants & Contributions	1	1.7		2.2		2.3		2.5	
Capital	1	—		—		—		0.1	
Health & Social Services—Total		17.3	50	18.7	53	18.6	60	6,701.9	544
Operating	5 & S	1.5		1.8		1.9		31.0	
Grants & Contributions	10	16.6		16.9		16.7		6,670.8	
Capital	5	—		<0.1		<0.1		<0.1	

Appendix II Science Expenditures by Vote for Major Funders (continued)

	Vote	Gross Science Resources						Total Voted Estimates	
		1980/81		1981/82		1982/83		1982/83	
		$M	PY	$M	PY	$M	PY	$M	PY
Medical Services—Total	15,20 & S	2.1	33	3.9	33	2.2	35	244.5	3,226
Health Protection—Total		38.0	1,126	41.3	1,175	50.3	1,194	92.5	1,896
Operating	25 & S	35.8		39.3		43.5		84.8	
Grants & Contributions	25	0.1		0.9		0.8		0.8	
Capital	30	2.0		1.2		6.0		6.9	
Income Security—Total	35 & S	0.5	17	0.6	16	0.9	20	12,254.4	2,848
Medical Research Council—Total		**82.0**	**39**	**100.2**	**39**	**112.9**	**39**	**112.9**	**39**
Operating	40 & S	1.6		1.8		2.0		2.0	
Grants & Contributions	45	80.5		98.4		110.9		110.9	
Capital	40	<0.1		<0.1		<0.1		<0.1	
National Research Council—Total		**226.1**	**3,158**	**297.4**	**3,248**	**360.7**	**3,341**	**349.6**	**3,341**
Scientific & Industrial Research—Total		211.4	2,935	278.8	3,016	339.0	3,107	331.2	3,107
Operating	5 & S	146.1		182.2		206.2		198.6	
Grants & Contributions	15	38.3		59.5		74.4		74.4	
Capital	10	27.0		37.0		58.4		58.2	
Scientific & Technical Information—Total		14.7	223	18.6	232	21.7	234	18.4	234
Operating	20 & S	14.5		18.3		21.3		18.0	
Grants & Contributions	20	—		0.1		0.1		0.1	
Capital	20	0.2		0.2		0.3		0.3	
Natural Sciences & Engineering Research Council—Total		**162.9**	**75**	**201.8**	**81**	**227.1**	**98**	**226.5**	**98**
Operating	25 & S	3.3		4.3		5.7		5.6	
Grants & Contributions	30	159.5		197.5		221.4		220.9	
Capital	25	0.1		<0.1		0.1		0.1	
Statistics Canada—Total		**144.1**	**4,619**	**230.0**	**5,489**	**187.2**	**4,576**	**179.1**	**4,576**
Operating	15 & S	140.7		229.3		186.5		178.4	
Grants & Contributions	15	0.1		0.1		0.1		0.1	
Capital	15	3.4		0.5		0.6		0.6	
Transport Canada—Total		**17.1**	**83**	**21.4**	**89**	**24.0**	**79**	**1,963.3**	**18,761**
Administration—Total		6.1	43	9.4	43	10.6	43	104.4	1,700
Operating	1 & S	6.0		9.4		10.6		92.0	
Grants & Contributions	1	<0.1		<0.1		<0.1		1.2	
Capital	5			—		—		11.2	
Marine Transportation—Total		8.5	21	8.9	29	9.9	17	540.2	6,561
Operating	10 & S	8.2		8.1		7.7		425.2	
Grants & Contributions	10	—		—		—		1.2	
Capital	15	0.3		0.8		2.2		113.9	
Air Transportation—Total		2.4	17	2.8	15	3.2	17	416.5	10,204
Operating	45 & S	2.3		2.7		2.9		292.1	
Grants & Contributions	55	—		—		—		24.1	
Capital	50	0.1		0.1		0.3		100.4	
Surface Transportation—Total		0.1	2	0.2	2	0.3	2	902.2	296
Operating	60 & S	<0.1		<0.1		<0.1		709.5	
Grants & Contributions	65	<0.1		<0.1		<0.1		190.3	
Capital	60	<0.1		<0.1		0.2		2.4	